DRAFT STAFF REPORT ON PROPOSED SITE-SPECIFIC WATER QUALITY OBJECTIVES AND EFFLUENT LIMIT POLICY FOR CYANIDE FOR SAN FRANCISCO BAY

November 10, 2005

California Regional Water Quality Control Board
San Francisco Bay Region

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1 Introduction

The Water Board's principal goal is to protect beneficial uses of waters of the state. Evidence exists that beneficial uses are protected with respect to cyanide at current ambient concentrations in the waters of the San Francisco Bay Region. The proposed Basin Plan amendment (BPA) is intended to improve the scientific basis for the cyanide marine (saltwater) objectives for the waters of the San Francisco Bay region and to alleviate an unnecessary regulatory burden on National Pollutant Discharge Elimination System (NPDES) permitted dischargers. The proposed action is needed to properly characterize the condition of the Region's marine and estuarine waters regarding cyanide and to avoid unwarranted widespread noncompliance with NPDES cyanide effluent limits, as documented in this staff report. The proposed action is consistent with state and federal law and regulations for adoption of water quality objectives and is consistent with the Water Board's charge under the California Water Code to provide protection of beneficial uses.

This staff report provides the background and basis of the proposed BPA to adopt site-specific water quality objectives (SSO) for cyanide in the San Francisco Bay Region, and a cyanide shallow water discharger effluent limitation policy. This staff report demonstrates why new SSOs are necessary and demonstrates that the proposed SSOs are protective of the most sensitive beneficial uses of the San Francisco Bay Region. Upon adoption, the proposed cyanide SSOs will lead to revised cyanide effluent limitations for deep water dischargers. The staff report also proposes a method of calculating and establishing effluent limitations for shallow water dischargers that is fully protective of beneficial uses.

Cyanide is a non-conservative toxic pollutant present in effluents and receiving waters at concentrations that could potentially affect aquatic life, but not at concentrations that would pose any risk to human health. Non-conservative pollutants chemically degrade to harmless by-products in natural waters over time, as opposed to conservative pollutants like elemental metals, which persist indefinitely under natural conditions. The persistence of conservative pollutants like copper and nickel necessitate the effluent limits required in association with site-specific objectives for Lower South San Francisco Bay, discussed in Sections 2 and 4. Small amounts of cyanide are formed in municipal wastewater treatment plants as a by-product of disinfection processes, such as chlorination. As a result, some dischargers cannot attain effluent limitations based on the U.S. EPA cyanide criteria. Recalculation of the U.S. EPA cyanide criteria, incorporating recent, peer-reviewed toxicity data, suggests that the cyanide criteria should be made less stringent. This recalculation was recently used to adopt modified water quality standards for cyanide by the State of Washington for Puget Sound. Adjusting the cyanide marine objectives for San Francisco Bay using the same rationale as for Puget Sound, through an SSO process, will result in effluent limitations for municipal dischargers that are both attainable and protective of beneficial uses.

The San Francisco Bay Basin Water Quality Control Plan (Basin Plan) contains water quality objectives applicable to the San Francisco Bay region. A water quality standard defines the water quality goals of a water body by designating the use or uses to be made of the water, by setting the numeric or narrative criteria ("objectives" in California) necessary to protect the uses, and by preventing degradation of water quality through antidegradation provisions (U.S. EPA, 1994). States adopt water quality standards to protect public health or welfare, enhance the quality of water, and implement the federal Clean Water Act (CWA). The CWA requires each state to adopt water quality standards that comply with federal requirements. A state that adopts water quality standards that are derived from the national federal water quality criteria published by U.S. EPA will have complied with the federal requirement. In California, water quality objectives adopted under the Porter-Cologne Water Quality Control Act are the numeric or narrative criteria that protect designated uses, and therefore function as part of an approvable water quality standard.

Water quality objectives for cyanide in the San Francisco Bay Region are based on the federal water quality standards adopted under the National Toxics Rule (NTR) in December 1992. The objectives for cyanide were adopted to protect sensitive marine and freshwater aquatic species in accordance with Section 303(c)(2)(B) of the Clean Water Act.

Investigations were recently conducted to evaluate the applicability of the existing marine objectives for cyanide in the San Francisco Bay Region. The findings suggest that recalculation of the existing marine objectives for cyanide is warranted.

NPDES-permitted dischargers in the San Francisco Bay Region are classified as either shallow or deep water dischargers. In order to be classified as a deep water discharge, waste must be discharged through an outfall with a diffuser and must receive a minimum initial dilution of 10:1, with generally much greater dilution. All other dischargers are classified as shallow water discharges. Shallow water dischargers in the San Francisco Bay Region have more stringent effluent limitations than deep water dischargers.

Work has been performed to indicate that the use of cyanide objectives as end-of-pipe effluent limitations for shallow water dischargers to the Bay may not be appropriate, given the relatively rapid decline in cyanide concentrations in the Bay away from points of discharge due to the effects of tidal mixing, dilution and degradation (this decline is termed “attenuation” in this report) and the absence of cyanide at levels of concern in the main body of the Bay.

Cyanide is known to be a non-conservative pollutant and therefore, after discharge, its concentration in receiving waters attenuates more rapidly than by simple dilution.

Consequently, the proposed BPA addresses these three topics:

1) adoption of the site-specific marine cyanide objectives for the protection of aquatic life uses in San Francisco Bay Region;
2) derivation and requirement of effluent limitations for deep water dischargers based on procedures established in the State Water Board's "Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California" (the State Implementation Plan or “SIP”) using a dilution ratio of 10:1; and
3) derivation and requirement of effluent limitations for shallow water dischargers that consider cyanide attenuation in the Bay and provide reasonable protection of aquatic life uses of the Bay.

The proposed BPA described in this report would 1) establish site-specific water quality objectives for cyanide marine and estuarine waters of the San Francisco Bay Region based on recalculation of the U.S. EPA criteria, and 2) establish a cyanide shallow water discharger effluent limitation policy, substituting an attenuation factor (AF), based on empirical studies, for the dilution factor (D) used in the calculation of effluent limitations, in accordance with procedures established in the SIP. All shallow and deep water municipal dischargers would receive effluent limitations for cyanide. For deep water dischargers, the calculation of effluent limitations for cyanide based on the new SSO would be determined using procedures in the SIP, currently using a 10:1 dilution ratio. This ratio may change in the future based on modifications to the Basin Plan dilution policy, if so ordered by the Water Board.

Allowing a dilution credit in the form of an attenuation factor is subject to approval by the Water Board contingent on whether conditions described in the Basin Plan are met. Appendix K of the staff report describes point-by-point how Basin Plan requirements for allowing shallow water discharger dilution credit have been met for cyanide.

The procedures for calculating and establishing effluent limitations and targeted surveillance and monitoring (a regional cyanide action plan, summarized in Section 9.3) constitute the implementation plan to achieve and support these site-specific water quality objectives. Thus, portions of Chapter 3 (Water Quality Objectives) of the Basin Plan will be revised to include the new objectives. Chapter 4 (Implementation) will be amended to describe required effluent limitations, the proposed attenuation factor for shallow water dischargers, and a brief narrative description of the regional cyanide action plan (see Appendix A).

Cyanide sources and pretreatment programs are described in Section 6.3. Most of the cyanide in effluents is formed in disinfection processes designed to protect recreational users of the San Francisco Bay Region waters (i.e., the designated beneficial use of water contact recreation or REC1) . The control of cyanide precursors appears infeasible at this time. Moreover, recent studies of attenuation of cyanide in receiving waters confirms that cyanide is non-conservative and that the proposed SSO, required effluent limitations, and additional surveillance and monitoring will enable compliance with federal and state antidegradation requirements. Therefore, with the exception of programs to prevent illicit discharge of cyanide to the sewer system, additional actions beyond existing pretreatment programs is not recommended.

2 Proposed Regulatory Changes

The staff report contains the analyses required by the Porter-Cologne Water Quality Control Act for the establishment of water quality objectives under Section 13241 of that Act. This Staff Report also serves as the document required by the California Environmental Quality Act (CEQA). The Water Board must comply with the requirements of CEQA when adopting Basin Plan amendments. CEQA authorizes the Secretary of the Resources Agency to certify a regulatory program of a State agency as exempt from the requirements for preparing Environmental Impact Reports, Negative Declarations, and Initial Studies if certain conditions are met. The process that the Water Board is using to adopt the proposed policy has received certification from the Resources Agency to be "functionally equivalent" to the CEQA process (Title 22, California Code of Regulations, Section 15251(g)). Therefore, this report serves as a Functional Equivalent Document and fulfills the requirements of CEQA for preparation of an environmental document. The environmental impacts that could occur as a result of the proposed action are discussed in the Notice of Filing and Environmental Checklist Form in Appendices H and I. Last, this Staff Report serves as the initial statement of reasons ("ISOR") required under Section 11346.2 of the California Administrative Procedures Act.

Three regulatory changes are proposed for the Basin Plan:

1) Establishment of site-specific objectives for cyanide in the marine and estuarine waters of the San Francisco Bay region;

2) Establishment of required effluent limitations derived from the proposed site-specific objectives for shallow and deep water municipal dischargers, and for industrial dischargers that apply disinfection, use cyanide in their processes and/or with detectable cyanide in the effluent; and

3) Reiteration of required effluent limitations for copper and nickel for municipal shallow water dischargers to San Francisco Bay south of Dumbarton Bridge.

The purpose of this Staff Report is to describe the necessity and justification for the adoption of a Basin Plan amendment to establish site-specific water quality objectives (SSO) for cyanide for the San Francisco Bay Region and to establish NPDES effluent limitations for cyanide that provide reasonable protection of aquatic life uses and address the attenuation of cyanide in ambient waters.

Proposed Basin Plan language is included in Appendix A describing the implementation of the cyanide SSO in NPDES permits for industrial and municipal dischargers, the latter of which are also referred to as publicly owned treatment works (POTWs). Appendix K fulfills the Basin Plan requirements for granting dilution credit to shallow water dischargers for cyanide.

For consistency, the effluent limitation requirements for the only other SSOs adopted for this region in 2002, copper and nickel for San Francisco Bay south of the Dumbarton Bridge, are clarified in proposed Basin Plan language in Appendix A. The Basin Plan language associated with the 2002 Basin Plan amendment states that copper and nickel "effluent limits will be calculated" for the three shallow water dischargers south of Dumbarton Bridge, Palo Alto, Sunnyvale, and San Jose/Santa Clara. In the subsequent permitting process of 2003, two of the three dischargers argued that effluent limits were not necessarily "required." These dischargers' interpretation conflicts with the applicable staff report of the Basin Plan amendment of May 2002 which states on page 33:

> "The IP [implementation plan] for maintaining the proposed SSOs [site-specific objectives for copper and nickel] includes continuation of provisions in the dischargers' NPDES permits that ensure that the treatment facilities continue to perform at highest efficiency. These provisions must also ensure that continuing efforts are being made to control all copper and nickel sources entering the treatment facilities, and that reasonable and cost-effective opportunities to reclaim wastewater are pursued. New concentration-based effluent limits for the three Lower South SF Bay POTWs will be calculated from the proposed chronic copper and nickel SSOs *and incorporated into their NPDES permits when those permits are re-issued*" (emphasis added).

Throughout the 2002 Basin Plan amendment documents, justification for less stringent water quality objectives is predicated on both the attainability and maintenance of copper and nickel effluent limits for Palo Alto, Sunnyvale and San Jose/Santa Clara, for instance on page 34 of the staff report:

> "After the proposed SSOs are adopted, the Regional Board intends to incorporate the water quality-based effluent limits into the NPDES permits during the next permit reissuance for the three Lower South SF Bay POTWs. Considering current performance, it is clear that all three Lower South SF Bay POTWs are in compliance with the effluent limits calculated from the proposed SSOs."

Whether the clarifying language for copper and nickel proposed in Appendix A is a regulatory change is a matter of debate, because of the above staff report language and the fact that the Water Board was led to believe in the public hearing of May 2002 that copper and nickel effluent limits derived from the SSOs would be required in permits, as demonstrated in the transcript of that hearing. Nevertheless, effluent limits are needed to hold discharges to current levels of performance to prevent accumulation of these conservative pollutants in the sediments and waters of the San Francisco Bay Estuary, and Appendix A includes language changes that remove ambiguity. Because effluent limitations derived from the site-specific objectives for copper and nickel are attainable (see staff report language above), there are no economic or environmental impacts of mandatory limits. There would be a potential environmental impact of removing effluent limits for copper and nickel, since it would erode the regulatory basis for copper and nickel local limits for industries discharging to these POTWs, and would potentially compromise the dischargers' abilities to meet the Basin Plan requirements to fully commit resources to ensure there is no degradation associated with adopting site-specific objectives.

3 Background and Existing Conditions

3.1 Description of San Francisco Bay Region

The proposed site-specific objectives (SSO) for cyanide would apply to marine and estuarine waters of the San Francisco Bay Region, excluding the Pacific Ocean. Water quality objectives for the ocean are established in the California Ocean Plan. The proposed marine SSO would apply to the following water bodies:

1) "San Francisco Bay," which for the purposes of this report, refers to the following water bodies, as shown in Figure 1 and 2:
    - A portion of the Sacramento/San Joaquin River Delta (within the San Francisco Bay region)
    - Suisun Bay
    - Grizzly Bay
    - Carquinez Strait
    - San Pablo Bay
    - Richardson Bay
    - Central San Francisco Bay
    - Lower San Francisco Bay
    - South San Francisco Bay (including the Lower South Bay)
    - Oakland Inner Harbor (part of Lower San Francisco Bay)
    - San Leandro Bay (part of Lower San Francisco Bay)

San Francisco Bay is a natural embayment in the Central Coast of California. With an average depth of six meters, the bay is broad, shallow, and turbid, which makes sediment an important factor in the fate and transport of particulate-bound pollutants such as copper and nickel. The movement of sediment within the bay is driven by daily tides, the spring-neap tide cycle, and seasonally variable wind patterns.

The bay is divided into two major hydrographic units, which are connected by the Central Bay to the Pacific Ocean. The northern reach is relatively well flushed because more than half of the California's freshwater flows into the bay through the Sacramento and San Joaquin Rivers. In contrast, the southern reach receives more limited fresh water inflow from local watersheds and is less well flushed.

2) Other marine and estuarine waters include: Tomales Bay, Drake's Estero, Limantour Estero, and Bolinas Lagoon.

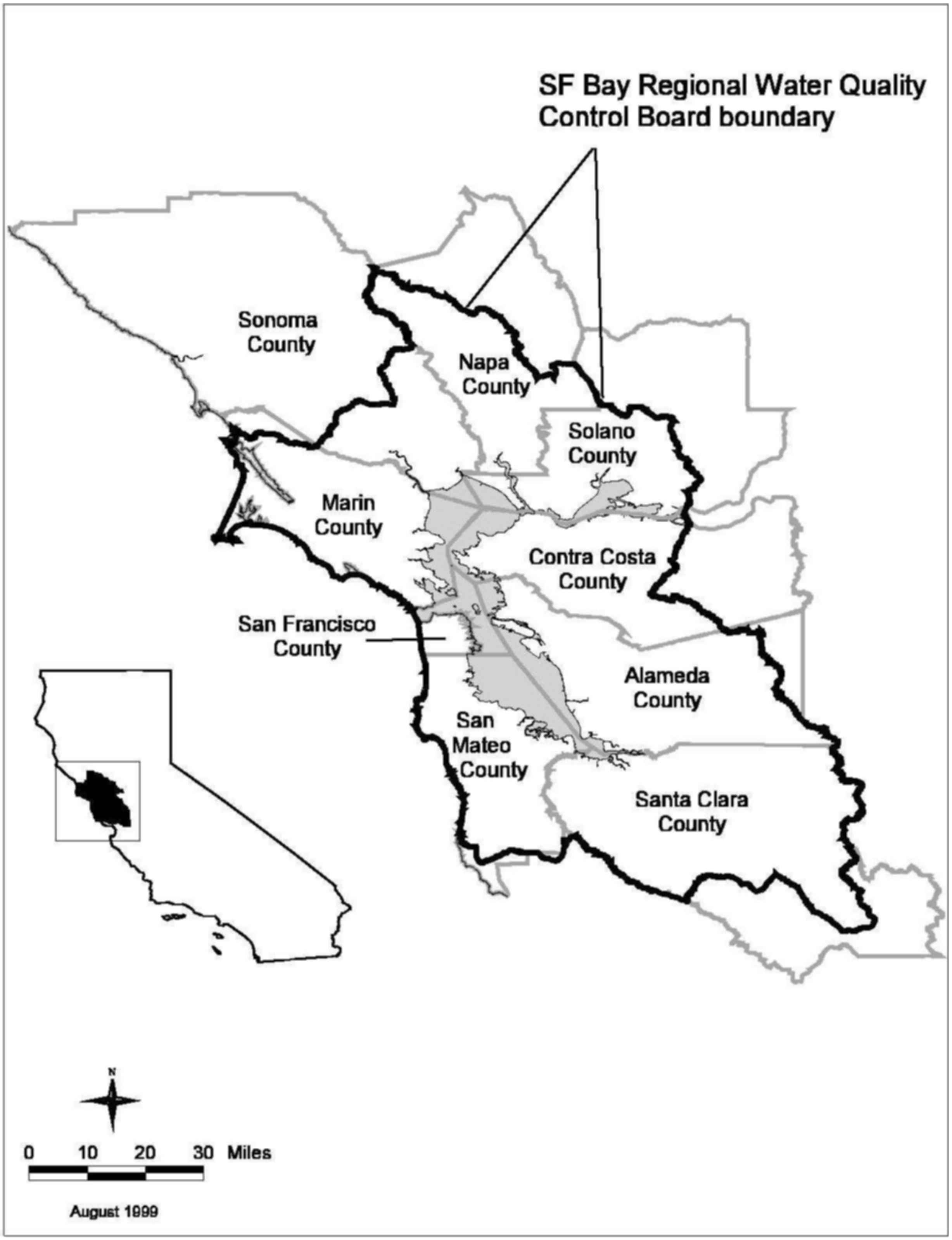


Figure 1: Map of San Francisco Bay Region

Figure 2: Eight Segments of the San Francisco Bay (indicated in larger font)

3.2 Project Background

A new site-specific objective and associated implementation plans are proposed for cyanide in the San Francisco Bay Region for two main reasons: to reflect best available scientific information regarding cyanide toxicity to aquatic organisms and to implement more appropriate NPDES effluent limit derivation procedures. Specifically, (1) the scientific basis of the federal criteria can be updated using recent information generated for completed regulatory changes in Puget Sound, Washington, and (2) effluent limits for cyanide based on the currently applicable federal criteria, developed in 1985, are not attainable and will cause non-compliance for some dischargers in 2005 and a majority of NPDES dischargers in the Region beginning in 2006. Scientifically-defensible effluent limits are proposed that will provide protection of sensitive beneficial uses in accordance with procedures contained in the Basin Plan and SIP.

Table 1 summarizes existing and proposed marine water quality objectives for cyanide. An objective of 1.0 µg/L (4-day average) was adopted for San Francisco Bay by U.S. EPA under the National Toxics Rule in 1992 (NTR objective). The NTR objective was based on the 1985 U.S. EPA ambient criterion for aquatic life protection (U.S. EPA, 1985b). It superseded the 1986 Basin Plan objective of 5.0 µg/L because it was more stringent and was based on U.S. EPA Section 304(a) criteria.

Table 1: Existing and Proposed Cyanide Objectives for Marine and Estuarine Waters

	Existing	Proposed
Acute	1 µg/L (NTR)	9.4 µg/L
Chronic	1 µg/L (NTR)	2.9 µg/L

The NTR objective has been demonstrated to be unnecessarily stringent. Recent work performed in Puget Sound using species native to San Francisco Bay has made available new scientific information to update the U.S. EPA criteria as well as provide justification for an adjustment of the cyanide objective for the San Francisco Bay Region (see Section 4.3)

At each permit adoption the Water Board determined that dischargers could not comply with final effluent limitations based on the NTR objective. Therefore, NPDES permits adopted in the San Francisco Bay Region all contain interim performance-based effluent limitations for cyanide (see Table 22). The interim limits have prevented immediate compliance problems, but those interim limits will be replaced by problematic final limits in the next round of NPDES permits, commencing in 2005.

3.3 Cyanide Chemical Composition, Sources, and Environmental Fate

Cyanide is a chemical compound with a carbon atom triple bonded to a nitrogen atom (CN). Inorganic cyanides contain the cyanide ion (CN^-) and are the salts of the acid hydrogen cyanide (HCN). These forms of cyanide, known as “free cyanide” are the most toxic to aquatic organisms. In natural waters in the pH range from 6.5 to 8.5, free cyanide is typically present in the hydrogen cyanide form (HCN).

The mechanism of cyanide toxicity occurs at the cellular level. The cyanide ion is toxic to aerobic organisms by shutting down respiration in cells, acting as an asphyxiant. Cyanide interrupts the electron transport chain in the inner membrane of the mitochondrion, thereby preventing proper combination of cytochromes with oxygen, interrupting the pathway energy is transmitted to living cells.

Cyanide compounds are typically classified as either simple or complex cyanides. Simple cyanides are those compounds that are readily converted to free cyanides (e.g. KCN, NaCN, NH_4CN). Complex cyanides are formed through the action of the cyanide ion as a ligand and its complexation with either metals (e.g. copper, iron, nickel, zinc) or with organics. Metallocyanides have widely varying stabilities and dissociate depending on a number of factors. Organic cyanides contain a carbon atom bonded to the CN group (also known as nitriles).

An important concern is the amount of free cyanide that is present in treated effluents, since free cyanide is the most toxic form to aquatic organisms. This is important since treatment plant effluent pollutants are sometimes highly complexed (Bedsworth and Sedlak, 1999). Currently, best available analytical protocols and detection limits do not allow for direct measurement of free cyanide levels in treated effluent at levels that would provide answers to this question, so the Water Board exercises a conservative assumption that all measured cyanide in effluent and in ambient waters is free cyanide.

As with any toxicant, cyanide effects are dependent on the concentration and duration of exposure. Toxicological tests have been performed which establish the knowledge base regarding cyanide toxicity to sensitive aquatic species at given concentrations and exposure durations. As a rule, the toxicity tests performed to date have exposed aquatic organisms to free cyanide concentrations in clean laboratory water.

Available scientific evidence indicates that cyanide is not teratogenic, mutagenic or carcinogenic to aquatic organisms. Additionally, available information indicates that cyanide is not bioaccumulated by aquatic organisms, ostensibly due to the fact that cyanide is highly reactive and readily metabolized (Eisler, 1991; U.S. EPA, 1985b; WERF, 2003).

Cyanide is commonly employed as an industrial reagent due to its many uses in chemical extraction processes. Hydrogen cyanide gas (HCN) is commonly used in the manufacture of plastics, for fumigation and pesticide use, and in the synthesis of other compounds such as nitriles. Sodium and potassium cyanide are used in gold mining, metallurgy, electroplating, and animal control.

Thiocyanate (SCN^-) is one of the major constituents of wastewater from factories for the gasification of coal, where various by-products are formed during the production of gas for fuel, coke, and substances for chemical industries. Cyanide is usually converted to thiocyanate by the addition reaction with sulfur since thiocyanate is less toxic than free cyanide. The resultant thiocyanate is then treated in an activated sludge process, where microbes degrade this substance.

Under normal conditions in natural surface waters, cyanide does not persist. It is considered a non-conservative pollutant and therefore degrades in natural waters due to processes of microbial utilization, volatilization, and photolysis (WERF, 2003, Chapter 8).

In receiving waters along the periphery of San Francisco Bay, cyanide discharged in wastewater effluents is also diluted through tidal mixing and turbulent diffusion in Bay waters. The combined effects of dilution and degradation leads to an *attenuation* in cyanide concentrations with distance from the point of input to the Bay.

3.4 Discharger Descriptions and Performance

A total of 46 public agencies and industries discharge treated wastewater directly to San Francisco Bay and its tributaries. Each of these discharges is permitted under the federal NPDES permit program, which is administered by the Water Board under a delegation agreement with the U.S. EPA.

A summary of cyanide effluent concentration data for individual NPDES dischargers is provided in Appendix C.

Implementation of the unnecessarily stringent NTR objective through the SIP would lead to unattainable effluent limitations, presenting compliance problems for the majority of municipal and industrial dischargers in the San Francisco Bay Region. Resultant water quality-based effluent limitations (WQBELs) would be less than 6 µg/L for deep water dischargers, and less than 1.0 µg/L for many shallow water dischargers. Neither of these limits would be consistently achieved in most effluents despite source control and treatment technologies.

Table 2 and Table 3 summarize projected final effluent limits for cyanide for Bay area POTWs and industries based on effluent limitation derivation procedures contained in Section 1.4 of the SIP and the existing NTR-based water quality objectives.

For shallow water dischargers to the Bay, no dilution credit is currently granted. As a consequence, the average monthly cyanide effluent limits for a given shallow water discharger would be 1.0 µg/L or less, depending on the variability of cyanide in the effluent in question. Available data indicate that none of the twelve shallow water dischargers examined can achieve the projected NTR-based cyanide effluent limits.

Table 2: Shallow Water Discharger Compliance Evaluation – Comparison of Existing Cyanide Concentrations to Projected NTR-Based Effluent Limits

NPDES Permittee	***Cyanide Effluent Concentrations (μg/L)***		***Coefficient of Variation (CV)***	***Projected Final Cyanide Effluent Limits (μg/L)***		***Projected Compliance Problem?***	***Interim CN effluent limits in current permit?***
	mean	***max***		***AMEL***[b]	***MDEL***[c]		
American Canyon	1.4	5.0	0.5	0.5	1.0	Yes	No [a]
Fairfield-Suisun Sewer District	3.9	28.0	1.0	0.4	1.0	Yes	Yes
Hayward Marsh	2.9	11.3	0.8	0.4	1.0	Yes	Yes
Las Gallinas Valley SD	3.0	10.0	0.8	0.4	1.0	Yes	Yes
Mt. View Sanitary District	0.5	3.0	0.6	0.5	1.0	Yes	Yes
Napa SD	2.6	20.0	1.2	0.4	1.0	Yes	Yes
Novato SD	1.8	4.4	0.7	0.5	1.0	Yes	Yes
Palo Alto, City of	3.3	4.8	0.3	0.7	1.0	Yes	Yes
Petaluma, City of	2.9	10.0	0.9	0.4	1.0	Yes	Yes
San Jose Santa Clara WPCP	2.8	5.2	0.4	0.6	1.0	Yes	No[d]
Sonoma County Water Agency	3.2	8.6	0.9	0.4	1.0	Yes	Yes
Sunnyvale, City of	4.4	29.0	0.9	0.4	1.0	Yes	Yes

Note: Projected effluent limits based on existing NTR objective for cyanide = 1 μg/L (chronic).
The mean and coefficient of variation were estimated using the probability regression method

[a] No interim limits granted to a new discharge. Final limit of 5 ug/l exists.

[b] AMEL= Average Monthly Effluent Limit.. The highest allowable average of daily pollutant discharges over a calendar month, calculated as the sum of all daily discharges measured during a calendar month divided by the number of measurements.

[c] MDEL=Maximum Daily Effluent Limitation. The highest allowable daily discharge of a pollutant, over a calendar day (or 24-hour period). For pollutants with limitations expressed in units of mass, the daily discharge is calculated as the total mass of the pollutant discharged over the day. For pollutants with limitations expressed in other units of measurement, the daily discharge is calculated as the arithmetic mean measurement of the pollutant over the day.

[d] No permit limits in existing permit due to an artifactual finding of no reasonable potential to cause or contribute to violation of the cyanide objective, due to review of effluent data limited to a certain time period. San Jose Santa Clara had three discharge events in 2004 that caused significant violations of the cyanide objective in San Francisco Bay waters (see Figure 3 of Appendix L). This example shows why the SIP reasonable potential calculation method can be misrepresentative of actual reasonable potential, and why the SIP grants the Water Board authority to make an independent finding of reasonable potential, discussed in Sections 2, 7.1 and 7.2.

For deep water dischargers to San Francisco Bay, a dilution credit of 10:1 has been implemented in the derivation of final effluent limits. Recent ambient monitoring data collected in 2002 and 2003, relevant to deep water dischargers indicates that the maximum observed cyanide concentration at the three ambient, deep water sites tested was 0.5 μg /L total cyanide. Using the existing NTR cyanide standard of 1.0 μg/L and effluent limit derivation equations contained in Section 1.4 of the SIP, the monthly average cyanide effluent limits for a given deep water discharger would be 5.5 μg /L, or less, depending on the variability of cyanide in the effluent in question.

Of the 25 deep water dischargers with adequate detected data, 14 (56%) will not comply with final effluent limits based on the NTR, 8 (32%) may not comply and 3 (12%) will likely comply. The nine deep water plants for which compliance uncertainty exists, do not have adequate detected cyanide concentration values to determine compliance based on the NTR.

Table 3: Deep Water Discharger Compliance Evaluation – Comparison of Existing Cyanide Concentrations to Projected NTR-Based Effluent Limits

NPDES Permittee	*Cyanide Effluent Concentrations (μg/L)*		*Coefficient of Variation (CV)*	*Projected Final Cyanide Effluent Limits (μg/L)*		*Projected Compliance Problem?*	*Interim CN effluent limits in current permit?*
	mean	*max*		*AMEL*	*MDEL*		
Benicia, City of	5.6	26.0	0.9	4.1	9.9	Yes	Yes
Burlingame, City of	3.3	13.0	0.6	4.5	9	Possible	Yes
Central Contra Costa Sanitary Dist.	3.8	9.9	0.4	4.8	8	No	Yes
Central Marin Sanitation Agency	4.3	16.0	0.7	4.4	9.4	Possible	Yes
Chevron Richmond Refinery	7.3	14.9	0.5	4.7	8.6	Yes	Yes
ConocoPhillips (at Rodeo)	6.1	14.0	0.4	4.8	8	Yes	Yes
Delta Diablo Sanitation District	7.1	13.0	0.6	4.5	9	Yes	Yes
Dow Chemical Company	3.3	5.7	0.6	4.5	9	No [a]	Yes
Dublin San Ramon Services District	7.0	8.8	ND	ND	ND	ND	Yes
EBDA	5.1	68.0	1	3.4	10	Yes	Yes
EBMUD	5.7	25.0	1.6	4.2	9.7	Yes	Yes
GWF E 3rd St (Site I)	7.5	10.0	0.6	4.5	9	Yes	Yes
GWF Nichols Rd (Site V)	7.4	10.0	ND	ND	ND	ND	Yes
Livermore, City of	14.9	25.0	ND	ND	ND	ND	Yes
Marin Co SD No. 5 (Tiburon)	5.0	5.0	0.6	4.5	9	Possible [b]	Yes
Martinez Refining Company	13.2	29.0	0.4	4.8	8	Yes	No/Possible
Millbrae, City of	3.7	18.0	0.7	4.4	9.4	Possible	Yes
Morton	7.5	10.0	ND	ND	ND	ND	Yes
Pinole-Hercules	3.5	10.0	0.5	4.7	8.6	Possible	Yes
Rhodia Basic Chemicals	10.0	10.0	ND	ND	ND	ND	Yes
Rodeo Sanitary District	3.7	7.0	0.3	5	7.5	No [a]	Yes
S.F. Airport Water Quality Control Plant	9.8	16.5	0.6	4.5	9	Yes	Yes
S.F. Airport, Industrial	9.8	10.0	ND	ND	ND	ND	Yes
S.F. City & County Southeast, North Point & Bayside	7.8	10.0	0.5	4.7	8.6	Possible	Yes
San Mateo, City of	4.3	15.0	0.5	4.7	8.6	Possible	Yes
Sausalito-Marin Sanitary District	9.6	20.0	0.5	4.7	8.6	Yes	Yes
South Bayside System Authority	7.8	14.7	0.4	4.8	8	Yes	Yes
South San Francisco & San Bruno	18.3	430.0	2.5	2.8	9	Yes	Yes
Tesoro Golden Eagle Refinery	8.8	28.0	0.5	4.7	8.6	Yes	No/Possible
US Navy Treasure Island	10.0	10.0	ND	ND	ND	ND	Yes
USS - Posco	8.8	10.0	ND	ND	ND	ND	Yes
Valero Benicia Refinery	10.0	15.0	ND	ND	ND	ND	Yes
Vallejo San. & Flood Control District	4.8	22.8	1.0	4	10	Yes	Yes
West County/Richmond	3.6	8.0	0.6	4.5	9	Possible [b]	Yes

Note: Projected effluent limits based on existing NTR objective for cyanide = 1 μg/L (chronic).
The mean and coefficient of variation were estimated using the half-detection method

[a] Limited number of detected values.

[b] Limited data set.

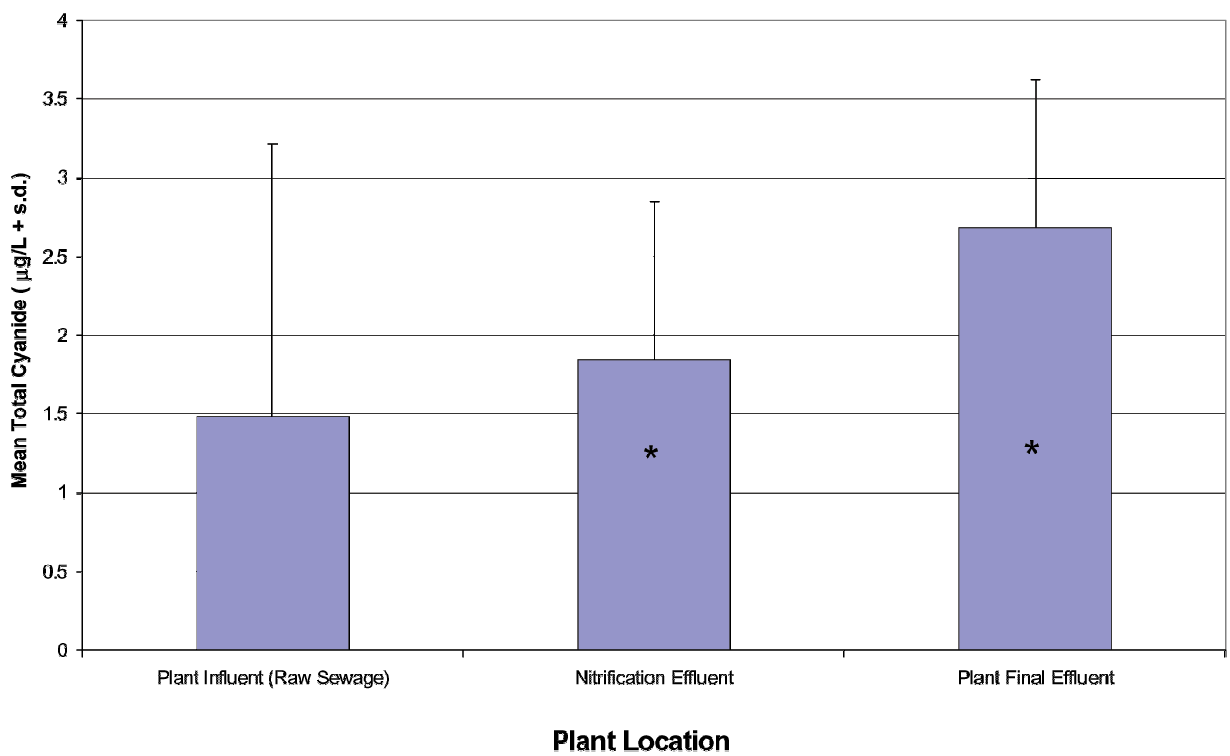
The data indicates that 12% of deep water dischargers can comply with projected final effluent limits, and none of the 12 shallow water dischargers can comply with NTR standard-based final effluent limits for cyanide.

A summary of effluent limits and compliance dates adopted in NPDES permits in the Bay is provided in **Error! Reference source not found.**. The significance of these compliance dates is that the five-year compliance schedule allowed under the SIP will have expired resulting in immediate non-compliance for Bay area POTWs.

3.5 Cyanide Levels in Influent and Effluent

In almost all cases, effluent cyanide concentrations at a given treatment facility are higher than influent cyanide concentrations. This in-plant increase is attributable to disinfection processes that protect recreational users of the San Francisco Bay Region waters (i.e., the designated beneficial use of water contact recreation or REC1). Figure 3, which shows the relationship between plant influent, within-plant concentrations (i.e., nitrification effluent), and plant effluent at the San Jose/Santa Clara Water Pollution Control Plant (WPCP), is characteristic of this relationship in the Bay area.

Figure 3 – San Jose/Santa Clara WPCP In-Plant Cyanide Measurements, Sept. 2003 - June 2004 [1]



Consistent with the influent/effluent relationship cited above, and as shown below in Table 4, effluent cyanide was above detection limits more often than influent cyanide for most of the POTWs (Publicly-Owned Treatment Works) providing data. Detection limits using USEPA-approved Standard Methods for total cyanide and/or weak acid dissociable cyanide range from 3 to 10 ug/l for the POTWs shown in Table 4.

[1] (omitting May 2004 high cyanide episode); n=25; * denotes significant difference between mean

Table 4: Effluent Cyanide Levels above Detection Limits for Bay Area POTWs[2]

DataSource	SampleType	Data Points	Percent Detected	Maximum Detection Limit (µg/L)
American Canyon, City of	Effluent	15	46.7%	5
Benicia, City of	Influent	14	35.7%	3
	Effluent	46	89.1%	3
Delta Diablo Sanitary District (DDSD)	Influent	65	15.4%	10
	Effluent	66	16.7%	10
Fairfield-Suisun Sewer District	Influent	65	13.8%	4
	Effluent	131	66.4%	3
Millbrae, City of	Influent	31	100%	---
	Effluent	42	100%	---
Napa Sanitation District	Influent	64	28.1%	3
	Effluent	91	25.3%	3
Palo Alto RWQCP	Influent	77	32.5%	3
	Effluent	273	37.4%	3
Petaluma, City of	Influent	36	25%	3
	Effluent	38	57.9%	3
San Francisco Southeast WPCP	Influent	265	11.3%	10
	Effluent	259	23.9%	10
San Jose/Santa Clara WPCP	Influent	70	4.3%	5
	Effluent	71	5.6%	5
San Mateo WWTP	Influent	43	11.6%	5
	Effluent	79	31.6%	6.8
Sonoma Valley County Sanitation District	Influent	53	64.2%	5
	Effluent	52	34.6%	5
South Bayside System Authority (SBSA)	Influent	47	97.9%	3
	Effluent	48	100.0%	---
Sunnyvale, City of	Influent	134	1.5%	5
	Effluent	137	19.7%	5
Union Sanitary District (USD)	Influent	22	27.3%	3
	Effluent	66	31.8%	3
Vallejo Sanitation & Flood Control District	Influent	66	37.9%	3
	Effluent	66	47.0%	3

3.6 Ambient Conditions

Knowledge of the ambient levels of cyanide in the water column of San Francisco Bay is important to the understanding of potential impacts of cyanide on aquatic life beneficial uses.

[2] Effluent Data from 2000 - 2003

Available information indicates that cyanide concentrations in the main body of San Francisco Bay are typically not detectable using standard analytical methods, and that ambient concentrations are below the existing 1.0 μg/L water quality objective. Recent data collected near shallow water dischargers indicate detectable levels in the receiving waters, sometimes above the current chronic and acute NTR objective of 1.0 μg/L, that decrease with distance from the discharge points.

Open Bay Conditions

Ambient concentrations of cyanide in deep water portions of the San Francisco Bay Region have been measured on several occasions since 1990. S.R. Hansen and Associates made the first measurements in a study performed for several Bay area oil refineries in 1989-1990. A second set of measurements were gathered in 1993 under the first year of the Regional Monitoring Program for Trace Substances (RMP), after which cyanide monitoring was discontinued due to lack of detectable values using a detection limit of 1.0 ug/L (SFEI, 1993). A third set of measurements were made by San Francisco Estuary Institute (SFEI) in 2002-2003 in response to a Water Code Section 13267 data request by the Water Board. BACWA and other Bay area NPDES dischargers funded this “CTR (California Toxics Rule) Ambient Monitoring Study.”

A description of the three cyanide ambient data sets is provided below.

Data collected by S.R. Hansen and Associates

This work was performed in 1989 and 1990. Data results are shown below in Table 5. The four monitoring stations for this work were located in San Pablo Bay (SP1) and (SP2), Carquinez Strait (CS) and Suisun Bay (SB). Each of these sampling sites are located in the deeper channels of the Bay. Samples were taken at flood tide at stations SP1 and CS and at ebb tide at stations SP2 and SB. QA/QC consisted of spikes on three occasions during the monitoring effort (January 1989, April 1989 and January 1990). Detection limits for the analytical work were 0.5 μg/L. A modification of cyanide test methods prescribed in American Society of Testing and Materials (ASTM) 1986 and American Public Health Administration (APHA) 1985 EPA were used to achieve the selected detection limits. Modifications included increasing the volume of sample distilled and decreasing the volume of NaOH scrubber solution (S.R. Hansen, 1990).

Table 5: Summary of Data Collected by SR Hansen and Associates (1989-1990)

Date	San Pablo Bay No. 1 (SP1)	San Pablo Bay No. 2 (SP2)	Carquinez Strait (CS)	Suisun Bay (SB)
April 1989	<0.5	<0.5	<0.5	<0.5
May 1989	<0.5	<0.5	<0.5	<0.5
June 1989	<0.5	<0.5	<0.5	<0.5
July 1989	<0.5	<0.5	<0.5	<0.5

Date	San Pablo Bay No. 1 (SP1)	San Pablo Bay No. 2 (SP2)	Carquinez Strait (CS)	Suisun Bay (SB)
August 1989*	8	6.5	6.8	<0.5
August 1989	<0.5	<0.5	<0.5	<0.5
September 1989	0.54	<0.5	<0.5	<0.5
October 1989	<0.5	<0.5	**<0.5**	<0.5
December 1989	<0.5	<0.5	<0.5	<0.5
December 1989	<0.5	<0.5	<0.5	<0.5
January 1990	<0.5	<0.5	<0.5	<0.5

* The extremely elevated detected values in August 1989 stand out as anomalies in the Hansen data set and in subsequent data sets. A re-sampling one week later on August 26, 1989 indicated no detectable levels at any of the four stations. Hansen was unable to explain the occurrence of these values in the technical report of this information. Absence of event specific QA/QC procedures precluded rigorous investigation of these results.

Data collected under the first year of the Regional Monitoring Program (RMP)

This work was performed in March, May and September 1993. Data results are shown below in Table 6. The sixteen monitoring stations for this work were located throughout the Bay, from the Sacramento River (BG20) and San Joaquin River (BG30) stations in the north to an extreme South Bay station (BA20) below the Dumbarton Bridge. Each of these sampling sites was located in the deeper channels of the Bay. Samples were taken at a depth of one meter at various tidal conditions. QA/QC followed protocols established for the RMP. Detection limits for the analytical work were 1.0 μg/L (SFEI online database at sfei.org).

Table 6: Summary of Data Collected by SFEI for RMP (March, May and September, 1993)*

RMP Station Number	RMP Station Name	Cyanide Concentration – total (μg/L)	Cyanide Concentration – dissolved (μg/L)
BA20	Extreme South Bay	<1.0	<1.0
BA30	Dumbarton Bridge	<1.0	<1.0
BA40	Redwood Creek	<1.0	<1.0
BB30	Oyster Point	<1.0	<1.0
BC10	Yerba Buena Island	<1.0	<1.0
BC20	Golden Gate	<1.0	<1.0

RMP Station Number	RMP Station Name	Cyanide Concentration – total (µg/L)	Cyanide Concentration – dissolved (µg/L)
BC30	Richardson Bay	<1.0	<1.0
BC41	Point Isabel	<1.0	<1.0
BD20	San Pablo Bay	<1.0	<1.0
BD30	Pinole Point	<1.0	<1.0
BD40	Davis Point	<1.0	<1.0
BD50	Napa River	<1.0	<1.0
BF10	Pacheco Creek	<1.0	<1.0
BF20	Grizzly Bay	<1.0	<1.0
BG20	Sacramento River	<1.0	<1.0
BG30	San Joaquin River	<1.0	<1.0

* Based on the above results, the decision was made to remove cyanide from the parameter list for subsequent RMP analyses.

Data collected by SFEI for CTR Ambient Monitoring

This work was performed in 2002 and 2003 at three RMP monitoring stations: Sacramento River (BG20), Yerba Buena Island (BC10), and Dumbarton Bridge (BA30). Data results are shown below in Table 7. The sampling sites are located in the deeper channels of the Bay. Samples were taken at a depth of one meter at various tidal conditions. Extensive QA/QC procedures were utilized during the sample collection and laboratory analysis performed, mirroring procedures employed by the RMP. Detection limits for the analytical work were 0.4 µg/L. Cyanide analyses were performed for SFEI by Central Contra Costa Sanitary District (SFEI, 2003).

Table 7: Summary of Data Collected by SFEI –CTR Ambient Monitoring (2002-2003)*

RMP Station Number	RMP Station Name	Dates	Cyanide Concentration – total (µg/L)
BA30	Dumbarton Bridge	January 2002	<0.4
		July 2002	<0.4
		January 2003	<0.4
BC10	Yerba Buena Island	January 2002	<0.4

RMP Station Number	RMP Station Name	Dates	Cyanide Concentration – total (µg/L)
		July 2002	<0.4
		January 2003	<0.4
BG20	Sacramento River	January 2002	<0.4
		July 2002	<0.4
		January 2003	0.5

* This data was collected using current clean methods for sampling and analysis.

Summary tables of the available ambient cyanide data for San Francisco Bay measured in samples taken from 1989 through 2003 are presented below in Table 8. The data in Table 5 to Table 7 show that ambient levels of cyanide at various deep water locations in the San Francisco Bay Region are consistently less than the existing NTR acute and chronic objectives for protection of aquatic life uses.

Table 8: Consolidated Summary Table of Data Collected at Overlapping Stations (1989-2003)

RMP Station Number	RMP Station Name	Mar-93	May-93	Sep-93	Jan-02	Jul -02	Jan-03
BA30	Dumbarton Bridge	<1.0	<1.0	<1.0	<0.4	<0.4	<0.4
BC10	Yerba Buena Island	<1.0	<1.0	<1.0	<0.4	<0.4	<0.4
BG20	Sacramento River	<1.0	<1.0	<1.0	<0.4	<0.4	0.5

Notes: Ambient levels are also important to the determination of effluent limitations for NPDES dischargers to San Francisco Bay. Ambient levels are used in the determination of whether a specific discharge has reasonable potential to cause or contribute to a violation of a water quality objective, and thus whether an effluent limit is required to be adopted in accordance with U.S. EPA regulations (40 CFR 122.44), and Section 1.3 of the SIP. Ambient levels are also used in the calculation of water quality-based effluent limits (WQBELs) for dischargers that receive credit for dilution, according to procedures in Section 1.4 of the SIP.

Conditions near Shallow Water Discharges

Recent data for the period 2003-2005 indicate that ambient levels in the immediate vicinity of shallow water discharger outfalls are detectable at levels ranging from 0.3 µg/L to 6.7 µg/L. Figures in Appendix B show the results of ambient monitoring of cyanide concentrations at various locations along individual discharge gradients for the following shallow water dischargers: American Canyon, Fairfield-Suisun, Las Gallinas, Napa, Mountain View Sanitary District (Martinez), Petaluma, Sonoma County Water Agency, Palo Alto, Sunnyvale and San Jose/Santa Clara. These dischargers collected a total of 225 local receiving water samples between 2003 and 2005 to inform the empirical derivation of an attenuation factor (Appendices B and D; Section 7.3) in the proposed calculation of effluent limitations. The average cyanide concentration in the vicinity of shallow water discharges was 0.9 ug/L, and the 90th percentile value was 2.2 ug/L.

As shown in Appendix B and D, especially for San Jose/Santa Clara for which there are more data, the ambient data collected near shallow water discharges demonstrates a pattern of rapid decline in cyanide concentrations with distance away from the point of discharge. As described previously, this “attenuation” (caused by a combination of degradation and dilution due to tidal mixing and dispersion) causes ambient cyanide levels to exist at levels that are protective of aquatic life beneficial uses in the open Bay and in the Bay margins near shallow water discharges.

Ambient monitoring of cyanide levels in San Francisco Bay indicates no evidence that cyanide concentrations pose a toxicity problem to aquatic species. The monitoring done to date has measured total cyanide levels, rather than free cyanide, the toxic form. Therefore, while the ambient data set is not as robust as that for trace metals, the ambient cyanide evaluation has an inherent factor of safety, since it is likely that a portion of the cyanide present in the Bay is complexed cyanide. Such complexed forms are not toxic to aquatic organisms at the levels of the existing or proposed cyanide objectives. Additionally, a biological study of one receiving water area conducted by a shallow water discharger is described in Section 7.3.4 and Appendix N suggests that current cyanide levels near discharge points are not adversely affecting aquatic life.

4 Derivation of Existing and Proposed Cyanide Criteria

4.1 Water Quality Standards, Criteria and Objectives

Before describing the details of the proposed cyanide water quality objective Basin Plan amendment, it is helpful to revisit the concept of a water quality standard since it is the basis of how water quality is regulated. A water quality standard defines the water quality goals of a water body by designating the beneficial uses to be made of the water, by setting the numeric or narrative criteria necessary to protect the uses, and by preventing degradation of water quality through antidegradation provisions. Under the California Water Code, the numeric or narrative criteria of the water quality standard are known as the "water quality objectives." States adopt water quality standards to protect public health or welfare, enhance the quality of water, and serve the purposes of the federal Clean Water Act. Numeric water quality criteria and objectives that are designed to protect aquatic organisms are generally of two types – the Criteria Continuous Concentration (CCC) or the Criteria Maximum Concentration (CMC).

The CCCs are the U.S. EPA national water quality criteria recommendations for the highest in-stream concentrations of a toxic pollutant to which organisms can be exposed on a long-term average basis without causing unacceptable effect (U.S. EPA, 2000). When adopted into California standards, the CCC becomes the chronic water quality objective for a given toxic pollutant. The CMCs are the U.S. EPA national water quality criteria recommendations for the highest in-stream concentrations of a toxic pollutant to which organisms can be exposed for a short-term average period of time without causing an acute effect. When adopted into California standards, the CMC becomes the acute water quality objective for a given toxic pollutant.

4.2 Existing Cyanide Water Quality Objectives

For the San Francisco Bay Region, existing cyanide objectives have been established through federal action under the National Toxics Rule 1992 (NTR), which superseded previous cyanide objectives from the 1986 Basin Plan, which were based on the level of detection of 5 ug/L. Existing water quality objectives for cyanide in San Francisco Bay are summarized in Table 9.

Table 9: Current Water Quality Objectives for Cyanide in San Francisco Bay Region (mg/L)

Source	Date	Description	Acute Objective	Chronic Objective
National Toxics Rule (NTR), (40 CFR 131.36)	December 22, 1992; amended May 4, 1995	Marine water[a] (waters with salinity greater than 10 ppt 95% of the time)	1 (one-hour average)	1 (4-day average)
NTR	December 22, 1992; amended May 4, 1995	Freshwater (waters with salinity less than 1 ppt 95% of the time)	22 (one-hour average)	5.2 (4-day average)

[a] Because marine objectives are more stringent than freshwater objectives the Basin Plan specifies that the marine objective applies for estuarine waters, where 95% of the time salinity is less than 10 ppt and greater than 1 ppt.

4.3 Proposed Cyanide Regulatory Changes

Of the above water quality objectives, Water Board staff is proposing changes to only the marine objective, based on a more complete data set for crabs of the *Cancer* genus. Only the marine objective poses significant compliance challenges for municipal and industrial NPDES dischargers of the San Francisco Bay Region. To Water Board staff's knowledge there is no compelling scientific information available at this time that suggests the freshwater objectives should be changed.

The Water Board staff has determined through best professional judgment and consideration of the fate and transport of cyanide in San Francisco Bay, that a regional approach to implementation of cyanide objectives for shallow water discharges to the Bay is appropriate. Therefore, the Water Board staff is proposing that effluent limitations which implement the proposed cyanide objectives for shallow water dischargers be based on an evaluation of cyanide attenuation in the Bay (i.e., via degradation and dilution) as a component of the program of implementation for San Francisco Bay Region cyanide objectives. Since this proposed policy for shallow water dischargers in effect grants dilution credit as part of a proposed attenuation factor, several Basin Plan requirements have been addressed, detailed in Appendix M. Section 9.2.1 describes the incorporation of a cyanide attenuation factor into the derivation of effluent limitations for shallow water dischargers.

4.4 Developing Site-Specific Objectives

California can choose to base state water quality objectives on the federal water quality criteria published by U.S. EPA (i.e., the basis of standards contained in the NTR and CTR) or can adopt site-specific water quality objectives provided they are based on an appropriate scientific justification.

Site-specific objectives may be developed where appropriate site-specific conditions warrant more or less stringent objectives, without compromising the beneficial uses of the receiving water. The State Board's "Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California" (the State Implementation Policy or "SIP") provides in Section 5.2 that a Water Board may consider site-specific objectives where an existing objective cannot be met through reasonable treatment, source control, and pollution prevention measures. The current applicable standards for cyanide are set forth in the NTR. As shown in Section 3.6 of this report, the NTR standards are not currently being met in all portions of San Francisco Bay.

Section 131.11(b)(ii) of the water quality standards regulation (40 CFR Part 131) provides the regulatory mechanism for states to develop site-specific criteria for use in water quality standards. There are several U.S. EPA-approved procedures (U.S. EPA, 1994) that can be used to modify national criteria so that they more accurately reflect ambient conditions and bioavailability. For this proposal, three procedures discussed below were evaluated and one was chosen as the basis for the site-specific objectives.

4.4.1 Recalculation Procedure

The proposed cyanide objectives are based on the recalculation procedure. It allows for modification to the national criterion by correcting, adding or removing data from the national toxicity database. Toxicity databases are collections of laboratory-measured toxicity values for different species and form the basis of water quality criteria promulgated by U.S. EPA. The goal of the recalculation procedure is to create a data set that is appropriate for deriving a site-specific criterion by modifying the national data set in some or all of three ways:

a) Correction of data that are in the national database;
b) Addition of data to the national database; and/or
c) Deletion of data that are in the national database (e.g. elimination of data for species that are not residents).

The proposed objectives rely on (b) and (c) above. The proposal includes addition of data for four species of the *Cancer* genus and deletion of data from *Cancer irroratus*, a species that exists only on the east coast of the United States.

4.4.2 Indicator Species Procedure

This procedure allows for modifications to the national criterion by using a site-specific multiplier called a water effects ratio (WER). Under the WER approach, the toxic substance of interest is added to clean laboratory water (to mimic the testing approach used in development of U.S. EPA criteria) and site water samples (to reflect local conditions) and toxicity tests are performed using sensitive organisms. The WER is the numeric ratio between the toxicity value (typically lethality to 50% of the organisms [LC50] or adverse effects to 50% of the organisms [EC50]) in local site water versus the toxicity value in clean laboratory water. The WER is then used as a multiplier in the following equation to produce a site-specific objective:

U.S. EPA national criteria X WER = Site-specific water quality objective

EPA (1994) guidelines specify that WERs may be developed for either acute or chronic criteria and that the test endpoint used to derive the WER should be near to but above the criterion that it is intended to modify**.**

Laboratory studies conducted by dischargers in the region could not generate a consistent WER value for cyanide, so this alternative was abandoned early in the process.

4.4.3 Resident Species Approach

This procedure is intended to account for differences in both resident species sensitivity and differences in toxicity due to local water quality characteristics.

Under the Resident Species procedure, data for species which are either resident or known to be present in the Bay are assembled or developed for use in criteria calculations. The minimum data requirements for development of national criteria must be met. Data used in the resident species procedure must pass the strict quality assurance and data quality requirements required for national criteria development.

For the marine cyanide objectives there were not enough data available for resident species to meet the minimum data requirements for a national criteria, so this alternative was abandoned early in the process.

4.5 Calculation of Proposed Cyanide Site-Specific Objectives

The proposed site-specific objectives for cyanide in the San Francisco Bay Region were developed based on the recalculation procedure. The recalculation was performed by adding recent toxicity data for four *Cancer* species to the existing U.S. EPA data set, deleting data from an east coast *Cancer* species, and recalculating the criteria values.

The calculation of water quality criteria for cyanide using the recalculation procedures includes several steps. The first step is using LC50 (lethal concentration to 50% of test organisms) toxicity data to arrive at a final acute value (FAV), and then the FAV becomes the basis for both the chronic criterion and the acute criterion. The FAV is derived from LC50 or EC50 values and is divided by two to calculate an acute criterion. Division by two is an approximation intended to estimate a concentration that will not adversely affect organisms (i.e. as a means to estimate the LC0 or EC0 value). The FAV is divided by an acute-to-chronic ratio (ACR) to produce a chronic criterion.

These calculations can be summarized as follows:

Acute Criterion = (FAV/2)
Chronic Criterion = (FAV/ACR)

4.5.1 Basis for Current U.S. EPA Marine Criteria for Cyanide

The Section 304(a) water quality criteria for cyanide were developed by the Environmental Research Laboratory of the U.S. EPA and published as national criteria in January 1985 (U.S. EPA, 1985b). These criteria were adopted into California water quality standards through the NTR. The cyanide marine criteria were derived using the minimum data set allowed by the U.S. EPA Guidelines (acute toxicity data for eight genera, chronic toxicity data for 5 freshwater and two saltwater species). The species and associated data used in the marine acute toxicity analysis are summarized in Table 10. The species used in this analysis include 3 fish families in the phylum Chordata, 4 families in the phylum Arthropoda (one mysid shrimp, one crab, one amphipod and one copepod) and one family in the phylum Mollusca (a gastropod). This assemblage of representative genera fulfilled the *minimum* allowed by U.S. EPA criteria guidelines.

Table 10: Data used in Calculation of Current Cyanide Marine Criterion (U.S. EPA, 1985b)[*]

Rank	Species	Genus Mean Acute Value (μg/L)
8	Common Atlantic slippershell, *Crepidula fornicata*	>10,000
7	Amphipod, *Ampelisca abdita*	995.9
6	Winter flounder, *Pseudopleuronectes americanus*	372
5	Sheepshead minnow, *Cyprinodon variegatus*	300
4	Mysid, *Americamysis bahia/bigelowi*	118.4
3	Atlantic silverside, *Menidia menidia*	59
2	Copepod, *Acartia clausi*	30
1	Eastern rock crab, *Cancer irroratus*	4.893

[*] U.S. EPA criteria calculations are based on GMAVs for organisms ranked 1 through 4. The FAV is calculated based on a regression equation using the GMAVs for the four most sensitive genera. Refer to Table 11 and Table 12 for the specific calculations used in the U.S. EPA criteria derivation.

Chronic toxicity data was available for a marine mysid, *Americamysis bahia* (formerly *Mysidopsis bahia*) and a marine fish (*Cyprinodon variegatus*) and five freshwater species (three fish, an amphipod and an isopod). The chronic values for these species were used to calculate acute-to-chronic ratios for each of these species. According to the U.S. EPA (1985c) guidelines, a final chronic value may be determined by one of eight different methods, which are summarized in the U.S. EPA 1995 Saltwater Copper Addendum. The acute-to-chronic ratio values for four freshwater species were used in the derivation of the final freshwater chronic value (FCV) by dividing the FAV by the ACR (U.S. EPA 1985b). However, Method 4 (U.S. EPA 1995) was used to derive a marine chronic value. Method 4 assumes that the ACR is 2 (CMC=CCC) because the acute tests used to derive the FAV were from embryo larval tests with molluscs, and a limited number of other taxa (*Cancer* sp. crabs in the case of cyanide). This assumption appears to be correct since the saltwater CMC of 1.015 ppb is 8-fold lower than the lowest observed "acceptable" freshwater chronic result (*Salvelinus fontinalus*), and 36-fold lower than the lowest observed "acceptable" saltwater chronic result (*Cyprinodon variegatus*) shown in the U.S. EPA cyanide criteria document (see Table 11).

No saltwater studies have been reported which show significant bioaccumulation or biomagnification in the aquatic food chain. Studies indicate that while cyanide may penetrate aquatic organisms, it readily metabolizes (U.S. EPA, 1985b).

Table 11: Calculations for Existing Cyanide Marine Criteria for San Francisco Bay

Rank	Genus species	Common Name	Phylum/Class/Family	GMAV	ln(GMAV)	ln(GMAV)2	P	(P)0.5	
1	Cancer irroratus	Eastern rock crab	Arthropoda/Crustacea/Cancridae	4.89	1.5872	2.5192	0.1111	0.3333	
2	Acartia clausi	Copepod	Arthropoda/Crustacea/Acartiidae	30	3.4012	11.5681	0.2222	0.4714	
3	Menidia menidia	Atlantic silverside	Chordata/Osteichthyes/Atherinidae	59	4.0775	16.6263	0.3333	0.5774	
4	Mysidopsis bahia/bigelowi	Mysid	Arthropoda/Crustacea/Mysidae	118.4	4.7741	22.7917	0.4444	0.6667	
5	Cyprinodon variegatus	Sheepshead minnow	Chordata/Osteichthyes/Cyprinodontidae	300					
6	Pseudopleuronectes americanus	Winter flounder	Chordata/Osteichthyes/Pleuronectidae	372					
7	Ampelisca abdita	Amphipod	Arthropoda/Crustacea/Ampeliscidae	995.6					
8	Credipula fornicata	Common Atlantic slippershell	Mollusca/Gastropoda/Calyptraeidae	10000					
		Count (n)	8						
		Sums			13.8400	53.5054	1.1111	2.0488	
		S2	= [Ln(GMAV)2 - Ln(GMAV)*Ln(GMAV)/4]/[P-P(0.5)*P(0.5)/4]						90.9781
		S	= SQRT (S2)						9.5382
		L	= [Ln(GMAV)-S/(P)0.05]/4						-1.4254
		A	= SQRT(0.05)*S+L						0.7074
		FAV	= Exp (A)						2.0288
		CMC	= FAV/2						1.0144
		FCV	Based on U.S. EPA judgment, FCV = CMC = CCC						1.0144

4.5.2 Basis for Current U.S. EPA Freshwater Criteria for Cyanide

The freshwater cyanide objectives are not proposed to be changed, but the basis of these objectives is discussed in this section, as they are considered in discharges to estuarine regions where freshwater and marine species overlap in occurrence. The 1985 U.S. EPA aquatic life criteria document (U.S. EPA, 1985b) describes the basis for calculation of the freshwater criteria for cyanide, which is currently a water quality objective for the San Francisco Bay Region as established under the NTR.

Data on the acute toxicity of free cyanide to 17 aquatic species of fish and invertebrates in 15 genera were used to derive the U.S. EPA freshwater acute criterion. The range in acute toxicity for the 17 species was from 44.73 μg/L to 2490 μg/L. The freshwater chronic criterion was calculated using acute and chronic data for four freshwater species. The species and associated data used in the acute and chronic freshwater criteria development are summarized in Table 13. The species used in this analysis include fish families in the phylum Chordata, families in the phylum Arthropoda and families in the phylum Mollusca. This assemblage of representative genera fulfilled the U.S. EPA criteria guidelines.

In the final freshwater criteria calculation, the species mean acute value (SMAV) for juvenile rainbow trout (previously referred to as *Salmo gairdneri,* now *Oncorhynchus mykiss)* (44.73 μg/L) derived from six separate study results performed between 1978 and 1984 was found to be more sensitive than the final acute value (FAV) calculated from the four most sensitive genera [rainbow trout and Atlantic salmon (*Salmo salar*), brook trout (*Salvelinus fontinalis*), yellow perch (*Perca flavescens*) and bluegill (*Lepomis macrochirus*), all fish families in the phylum Chordata]. In accordance with U.S. EPA water quality criteria guidance, the rainbow trout SMAV replaced the calculated FAV. The most sensitive invertebrate (*Daphnia*) was more than two-fold less sensitive than rainbow trout.

The freshwater acute criterion (CMC) of 22.4 μg/L was derived by dividing the rainbow trout SMAV-based FAV of 44.73 μg/L by 2 (to approximate a "no effect" value from the EC50 value [effects concentration affecting 50% of organisms] for rainbow trout). The freshwater chronic value (CCC) of 5.2 μg/L was derived by dividing the FAV (44.73 μg/L) by an acute to chronic ratio of 8.57 (geometric mean of values from four freshwater species). The most sensitive chronic toxicity value used in criteria derivation in 1985 was 7.85 μg/L for brook trout (*Salvelinus fontinalis*), a sensitive species to cyanide.

No freshwater studies have been reported which show significant bioaccumulation or biomagnification of cyanide in the aquatic food chain (U.S. EPA, 1985).

Table 12: Calculations for U.S. EPA Cyanide Freshwater Criteria (U.S. EPA, 1985). Existing U.S. EPA Criteria

Rank	Genus species	Common Name	SMAV	GMAV	ln(GMAV)	ln(GMAV)2	P	(P)0.5	
1	Oncorhynchus mykiss	Rainbow trout	44.73	63.45	4.1503	17.2246	0.0625	0.2500	
	Salmo salar	Atlantic salmon	90						
2	Salmo salvelinus	Brook trout	85.8	85.8	4.4520	19.8205	0.1250	0.3536	
3	Perca flavescens	Yellow perch	92.64	92.64	4.5287	20.5093	0.1875	0.4330	
4	Lepomis macrochirus	Bluegill	99.28	99.28	4.5979	21.1411	0.2500	0.5000	
5	Pomoxis nigromaculatus	Black crappie	102	102					
6	Micropterus salmoides	Largemouth bass	102	102					
7	Daphnia magna	Cladoceran	160	123.6					
	Daphnia pulex		95.55						
8	Pimephales promelas	Fathead minnow	125.1	125.1					
9	Poecillia reticulata	Guppy	147	147					
10	Gammarus pseudolimnaeus	Amphipod	167	167					
11	Carassius auratus	Goldfish	318	318					
12	Pteronarcys dorsata	Stonefly	426	426					
13	Physa heterostropha	Snail	432	432					
14	Asellus communis	Isopod	2326	2326					
15	Tanytarsus dissimilis	Midge	2490	2490					
	Count (n)	15							
	Sum				17.7289	78.6955	0.6250	1.5366	
	S2	= [Ln(GMAV)2 - Ln(GMAV)*Ln(GMAV)/4]/[P-P(0.5)*P(0.5)/4]							3.3584
	S	= SQRT (S2)							1.8326
	L	= [Ln(GMAV)-S/(P)0.05]/4							3.7283
	A	= SQRT(0.05)*S+L							4.1380
	FAV	= Exp (A)							62.6798
	Calculated CMC	= FAV/2							31.3399
	Sensitive Species-based CMC (based on species mean acute value for rainbow trout)					= 44.73/2			22.3650
	FCV (based on Rainbow trout SMAV divided by ACR for four freshwater species)					=44.73/8.57			5.2194

Table 13: Data Used in U.S. EPA Cyanide Chronic Freshwater Criteria Derivation (U.S. EPA, 1985)

FW[a] or SW[b]	Rank[c]	SMAV[d]	SMACR[e]	SMCV[f]	Species	Common name
SW	5	300	8.306	36.12	*Cyprinodon variegatus*	Sheepshead minnow
SW	4	113	1.621	69.71	*Americamysis bahia*[g]	Mysid
FW	14	2326	68.29	34.06	*Asellus communis*	Isopod
FW	10	167	9.111	18.33	*Gammarus pseudolimnaeus*	Amphipod
FW	8	125.1	7.633	16.39	*Pimephales promelas*	Fathead minnow
FW	4	99.28	7.316	13.57	*Lepomis macrochirus*	Bluegill
FW	2	83.14	10.59	7.849	*Salvelinus fontinalus*	Brook trout
			1.621	7.849	Minimum	
			68.29	34.06	Maximum	
			8.306		Median ACR (all)	
			9.05		Geometric Mean ACR (all)	
			8.37		Median ACR (Freshwater only minus Asellus)	
			8.57		Geometric Mean ACR (Freshwater only minus Asellus)	

[a] Fresh Water
[b] Salt Water
[c] Rank is based on sensitivity to cyanide, with the most sensitive genus ranked no. 1
[d] SMAV= species mean acute value
[e] SMACR = species mean acute to chronic ratio
[f] SMCV= species mean chronic value
[g] formerly Mysidopsis bahia

4.5.3 Proposed Cyanide Marine Site-Specific Objectives for the San Francisco Bay Region

The SIP requires that site-specific water quality objectives "be developed in a manner consistent with State and federal law and regulations." In accordance with the State's Porter-Cologne Water Quality Control Act (Division 7 of the Water Code), objectives must provide for the reasonable protection of beneficial uses based on consideration of the factors listed in Water Code Section 13241. In accordance with federal law (CWA) and regulations (40 CFR 131.11, revised as of July 1, 1997), the objectives must be "based on sound scientific rationale and protect the designated beneficial uses of the receiving water." The SIP further requires that the "RWQCB shall use scientifically defensible methods appropriate to the situation to derive the objectives. Such methods may include U.S. EPA-approved methods (e.g. Water Effects Ratio (WER) procedure, recalculation procedure, a combination of recalculation and WER procedures, Resident Species Procedure), and/or other methods…"

Section 7.3.5 describes the different U.S. EPA-approved methods reviewed to address the cyanide compliance issue in the San Francisco Bay Region.

The 1985 cyanide marine criteria values are significantly affected by the acute toxicity value (LC50) for one species (*Cancer irroratus*, the Eastern rock crab). This acute value has been scrutinized by researchers (Brix et al., 2000) and has been found to be significantly different from the acute values for other *Cancer* species.

It is proposed that the cyanide marine site-specific objectives be derived through application of the U.S. EPA recalculation approach by using acute toxicity test results for four crab species (*Cancer magister, Cancer productus, Cancer gracilis, and Cancer oregonensis*) to replace the existing data for *Cancer irroratus* used in the 1985 U.S. EPA cyanide criteria. A slight variation of this approach was performed and approved in the adoption of cyanide standards in Puget Sound, located in U.S. EPA Region 10. The resulting Genus Mean Acute Value (GMAV) derived from the consideration of crab data for four species is then used in the recalculation of the cyanide water quality objectives. It is also suggested that an Acute to Chronic Ratio (ACR) value of 6.46 be used in the derivation of the cyanide chronic criterion. The ACR value of 6.46 was calculated using all ACR values in the 1985 U.S. EPA criteria document except the ACR value for *Asellus communis*. The ACR value for *Asellus communis* was excluded from the 1985 U.S. EPA freshwater criteria calculations by U.S. EPA criteria experts in accordance with U.S. EPA guidance because its magnitude was significantly different from the other available ACR values.

The four additional acute toxicity values for *Cancer* spp. were developed by Parametrix, Inc. and EcoTox in 1995 using West Coast species as part of a study to derive site-specific cyanide marine objectives for Puget Sound in Washington (Parametrix, 1995; Brix et al., 2000). The four additional values are presented in Table 14, below *Cancer irroratus*. The results indicated significantly higher LC50 values for each of the *Cancer* species tested than the LC50 value stated for the Eastern rock crab (*Cancer irroratus*) in the U.S. EPA cyanide criteria document. The net effect of adding the data for these four crab species into the data set was to increase the GMAV for *Cancer* from 4.9 μg/L to 62.6 μg/L. The GMAV without the *Cancer irroratus*

SMAV is 118.4 ug/l. In the recalculation for the proposed cyanide SSO, it is proposed that the GMAV without *Cancer irroratus* be used.

Table 14: Summary of Available Acute Toxicity Saltwater Data for Five Crab Species (*Cancer* spp.)[a] (Ref: Brix et al., 2000)

Species	Species Mean Acute Value (μg/L)	Genus Mean Acute Value (μg/L)
Cancer irroratus[b]	4.9	
Cancer magister	68.5	
Cancer productus	153.1	
Cancer gracilis	143.7	
Cancer oregonesis	130.7	
Cancer spp (with *Cancer irroratus)*		62.6
Cancer spp (without *Cancer irroratus)*		118.4

[a] Three additional West Coast Cancer species are known to exist in San Francisco Bay (C. anthonyi, C. antennarius, and C. jordani). No data are available for these species to assess sensitivity to cyanide.
[b] This species (Eastern rock crab) is not present in San Francisco Bay.

The recalculated site-specific objectives are based on the revised Cancer GMAV and the ACR value. See Table 15 for the values used to derive the recalculated cyanide marine criteria. See Table 1 for the existing and proposed site-specific objectives for cyanide in the San Francisco Bay Region.

U.S. EPA criteria documents and the Technical Support Document for Water Quality-Based Toxics Control (U.S. EPA, 1991, Appendix D) state that beneficial uses will be protected if the 304(a) criteria values are not exceeded more than one time in three years, particularly acute criteria. The same allowable exceedance frequency is presumed to apply to these recalculated cyanide objectives.

Table 15: Calculations for Proposed Cyanide Saltwater Site-Specific Objectives for San Francisco Bay

	Rank	*Genus*	*Common Name*		*GMAV*	*ln(GMAV)*	*ln(GMAV)2*	*P*	*(P)0.5*	
	1	*Acartia clausi*	Copepod		30	3.4012	11.5681	0.1111	0.3333	
	2	*Menidia menidia*	Atlantic silverside		59	4.0775	16.6263	0.2222	0.4714	
	3	*Cancer spp*	Crabs	*(Excludes Cancer irroratus at 4.89 ug/l)*	118.4	4.7741	22.7917	0.3333	0.5774	
	4	*Mysidopsis bahia/bigelowi*	Mysid		118.4	4.7741	22.7917	0.4444	0.6667	
	5	*Cyprinodon variegatus*	Sheepshead minnow		300					
	6	*Pseudopleuronectes americanus*	Winter flounder		372					
	7	*Ampelisca abdita*	Amphipod		995.6					
	8	*Credipula fornicata*	Common Atlantic slippershell		10000					
Count (n)	8									
Sum						17.0269	73.7779	1.1111	2.0488	
S2										21.0376
S										4.5867
L										1.9075
A										2.9331
FAV										18.7855
CMC										**9.3928**
ACR										6.4600
FCV										
CCC										**2.9080**

5 Cyanide Analytical Methods

Cyanide measurements for NPDES permit compliance in the San Francisco Bay Region are based on either total cyanide or weak acid-dissociable (WAD) cyanide measurements using Standard Methods 4500-CN or USEPA Method 335. The total cyanide analytical method attempts to measure all cyanide species that may dissociate in the environment over time due to varying conditions of heat, light, hardness and pH. These species include the toxic free cyanide species (CN- and HCN), weak and moderately strong metal-cyanide complexes of silver, cadmium, copper, mercury, nickel and zinc, and the strong metal-cyanide complexes of iron. The WAD method attempts to measure theoretically "available cyanide" (i.e. cyanide that dissociates in the presence of acid), again seeking to measure either free cyanide or the weak or moderately strong metal-cyanide complexes that may become free over time in the environment. Free cyanide test methods (ASTM D4282-02) measure free cyanide in water and wastewater by microdiffusion. Neither total cyanide nor WAD analytical methods provide specific information regarding the cyanide forms (e.g. free cyanide or metal-cyanide complexes) present in a sample. Both methods therefore overestimate, to an unknown degree, the toxic forms of cyanide by including relatively non-toxic iron-cyanide complexes and other less toxic metal-cyanide complexes.

For the purpose of the compliance analyses described in this report, reported data from NPDES dischargers for the period 2000 to 2004 has been utilized. This data has been developed using Standard Methods 4500-CN, typically with reporting limits in the 3 to 5 ug/l range. It is appropriate to use this data for the compliance analysis since NPDES dischargers must use analytical methods approved by U.S. EPA under 40 CFR Part 136 in monitoring for compliance with effluent limits. Future monitoring for cyanide will continue to use these methods unless U.S. EPA approval for another method is granted.

The City of San Jose developed a modified version of Standard Method 4500-CN to obtain reduced detection limits for cyanide in effluent and receiving waters. The analytical method developed by San Jose was used in the analysis of effluent and receiving water data collected by shallow water dischargers that is summarized in Appendices B and D. A brief description of the modified method developed and used by San Jose is included in Appendix M.

Use of the San Jose analytical method provided improved insight into the actual levels of cyanide in effluents and in ambient waters near shallow water discharges and was essential in the determination and evaluation of attenuation factors for these discharges. The reporting limits for the San Jose analytical method were 1.0 ug/l in effluent and 0.3 ug/l in ambient waters. The use of these research methods for characterizing ambient concentrations and evaluating options for determining effluent limitations is appropriate. However, a distinction must be made regarding the use of this data in the NPDES permit compliance assessments. In that case, data resulting from U.S. EPA-approved analytical methods must be used to reflect future compliance capabilities. Therefore, effluent data from the special effluent and receiving water studies performed by the City of San Jose and other shallow water dischargers were not used in the compliance assessments described in this report.

Some uncertainties have been identified regarding interferences that may affect the cyanide concentration data that is generated by NPDES dischargers using Standard Methods. In its special study, the City of San Jose reported that the addition of NaOH as a preservative to bring de-chlorinated tertiary effluent samples up to pH 12 prior to cyanide analysis (in accordance with Standard Method 4500-CN-E) resulted in increased total cyanide measurements. In a controlled experiment by San Jose where flasks were sealed to prevent the loss of cyanide, samples with NaOH preservative added to pH 12 exhibited a 75 percent increase in measured cyanide concentration (2.1 ug/l versus 1.2 ug/l) as compared to unpreserved samples(City of San Jose, 2004). Similar results were observed by the County Sanitation Districts of Los Angeles County (Khoury et al, in press), who found that unpreserved sample concentrations were less than a reporting limit of 5 ug/l in all samples, whereas samples preserved to pH 12 were above 5 ug/l in 18 percent of the samples where thiosulfate was used as a de-chlorinating agent and in 97 percent of the samples where arsenite was used to as the de-chlorinating agent. Others have found that use of ascorbic acid as a dechlorination compound has caused an upward bias in cyanide measurements. WERF researchers (Zheng, et al, 2004) have found that (a) thiocyanate in combination with nitrate and (b) nitrite in combination with specific trace organic compounds (aromatics such as phenol and benzoic acid) can produce cyanide during total cyanide analysis that biases cyanide measurements upward. These researchers recommended sufficient addition of sulfamic acid at the time of sampling to avoid upward-biased cyanide results due to nitrite/organics reactions (known as nitrosation).

Various compounds are also known to interfere with cyanide measurements, as follows:

- Oxidizing Agents – Presence of residual oxidizing agents in samples, such as free chlorine, can negatively bias results due to decomposition.

- Sulfide – Sulfides are known interferents of cyanide measurement as they can distill over with cyanide when performing an analysis and interfere with colorimetric measurements or react with cyanide to form thiocyanate.

- Aldehydes – Aldehydes can convert cyanide into cyanohydrin, thus negatively biasing results.

The above findings indicate that consideration of refinements to U.S. EPA approved sampling and analytical methods should be made to ensure that cyanide measurements reported for NPDES compliance are accurate.

The uncertainties associated with varying methodologies, the potential for interference introduced during sample handling or analysis, and the fact that many reported historical results are at or near the reporting limit, all combine to make it difficult to confidently compare influent/effluent data from different treatment plants across the country. Historically POTWs have measured “total CN^-,” which, as described above, includes free cyanide, weak metal-cyanide complexes, and strong metal-cyanide complexes. Furthermore, detection limits have historically been at or above 5 µg/L, in the range of typical effluent values, and above ambient levels. Adoption of uniform methods for sampling and analysis of total cyanide in Bay area effluents will be evaluated as part of the Cyanide Action Plan in the San Francisco Bay region.

6 Cyanide Source Characterization

Cyanide sources are limited to POTWs and industries, collectively known as point source dischargers. Several Bay area POTWs have completed cyanide source identification studies, some as a condition of having interim effluent limits, to determine the origins of the cyanide in their effluent. Results show that the predominant source of effluent cyanide is typically generated in-plant through municipal and industrial wastewater treatment processes (disinfection or biosolids incineration). In some cases, cyanide that enters municipal treatment plants from industrial, commercial and residential sources may influence effluent concentrations of cyanide (see Appendix L).

6.1 Cyanide in Municipal Influent

Available data from POTW facilities show that influent concentrations of cyanide are often not detected, or are present at levels below effluent cyanide concentrations. Recent and historic (over ten years old) data both indicate that higher influent values are an episodic occurrence, sometimes traceable to illicit discharges in the collection system.

Where observed in municipal wastewater influent, cyanide may originate from industrial activities, such as metal plating, steel production, mining operations, or photographic finishing facilities (WERF, 2003). Other commercial or industrial operations that may utilize or discharge cyanide include metal finishing, electroplating, hospitals, manufacturing, chemical laboratories, and chemical manufacturing facilities. In several Bay area studies completed to date, these sources have been considered insignificant based on mass balance calculations that demonstrate their relative contributions to wastewater treatment plant influent. A study performed for Sacramento Regional County Sanitation District detected cyanide in 5% of residential wastewater samples taken, suggesting that residential wastewater is a minor source of cyanide loading (SRCSD, 2003). Formation of cyanide in the collection system as a result of chemical treatments or maintenance activities is also a possible source of cyanide in influent.

Thiocyanate (SCN^-) in influent is a potential precursor of cyanide in effluent. Little is currently known about the amount of thiocyanate in POTW influent, as it is currently an unmonitored and unregulated constituent. There is a question as to whether thiocyanate may be a significant and controllable precursor for cyanide formation in wastewater treatment. WERF (2003) researchers have found that chlorination of thiocyanate seems to be an important mechanism for the formation of cyanide in wastewater treatment. LACSD (2005) tested thiocyanate levels at various points in the wastewater treatment process and found that elevated levels of thiocyanate in raw wastewater and primary effluent were reduced significantly in the secondary (biological) process, indicating that thiocyanate is biodegradable. This result is generally consistent with the WERF findings. However, the LACSD investigators found that use of an ion chromatography analytical method, that avoided interferences inherent in the colorimetric methods used in the WERF study, yielded much lower thiocyanate measurements in effluent. This result raises doubt whether levels of thiocyanate in effluent are capable of causing cyanide formation at previously reported levels. Since thiocyanate is not measured in the total cyanide test, a question exists whether influent levels of thiocyanate may explain observed cyanide levels in effluent. A more detailed discussion of thiocyanate is presented in Section 6.2.1.

6.2 Cyanide Formation in Wastewater Treatment

Cyanide, cyanide precursors, and cyanide complexes can undergo various transformations during the wastewater treatment process for municipal and industrial dischargers. Chlorination, UV disinfection, and incinerator scrubber return flows have been implicated as sources of cyanide formation during wastewater treatment and sources of cyanide detected in effluent (Zheng et al., 2004a; Zheng et al., 2004b; SRCSD, 2003). In-plant cyanide formation is not limited to POTWs; any discharger that disinfects or incinerates may produce cyanide in their effluent.

Investigations of cyanide formation in wastewater treatment can be confounded by the presence of interferences that produce false negatives or false positives introduced as a result of sample handling, preservation or analytical methods. Additionally, limitations on the detection levels of total cyanide, free cyanide and thiocyanate have hampered our understanding of cyanide formation (see Section 5).

As also described in Section 5, other compounds that can affect the formation or measurement of cyanide in wastewater effluent include nitrate, nitrite, sulfide, aldehydes, and uncharacterized organic matter.

6.2.1 Chlorination

Chlorination was the first process to be identified as causing formation of cyanide within treatment plants. Oxidative decomposition of thiocyanate using chlorine can produce free cyanide. Thiocyanate is known to be used or generated in various industrial processes, including photofinishing, coke gasification, herbicide and insecticide production, ore mining process, and dyeing and electroplating (Zheng et al., 2004a; WERF, 2003). Zheng et al.2004a and 2004c showed cyanide formation from thiocyanate to be dependant on chlorination levels. Treatment plant influent from two plants was used in the study. None of the treatment plant influent samples had detectable levels of thiocyanate. When spiked with thiocyanate, approximately 1-6% of the thiocyanate was converted to cyanide during chlorination of the effluent. The cyanide was formed as a result of non-stoichiometric amounts of chlorine being applied.

The above case study can be applied to a hypothetical example, which suggests that thiocyanate probably does not explain the majority of cyanide formed in chlorination processes in treatment plants. Extrapolating the study results above, if an industrial facility discharges 100,000 gal/day containing 5 mg/L thiocyanate to the collection system of a 10 MGD plant, the approximate thiocyanate concentration in the POTW influent would be 0.05 mg/L. If 6% of the thiocyanate were converted to cyanide, it would add approximately 0.3 μg/L of cyanide to the effluent, which is below the levels of concern (i.e., 1 to 3 μg/L). Therefore, unless an industry is identified that discharges large amounts of thiocyanate, influent thiocyanate levels are unlikely to significantly impact cyanide levels in POTW effluents in the San Francisco Bay Region.

Thiocyanate concentrations measured in POTW influent have been observed to decrease in secondary influent by 60% (WERF, 2003; Zheng et al., 2004b), suggesting significant removal in primary treatment. However, a positive correlation between thiocyanate decrease and cyanide increase could not be established, suggesting multiple factors contributing to the cyanide formation.

Other organocyanide compounds also have the potential to elevate cyanide concentrations in post-chlorinated effluent, although these effects are not well understood. Compounds studied include acetonitrile, D-Amygdalin, 2-acetoxy-3-butenenitrile, and cyanobalamin.

6.2.2 UV Disinfection

Available information on cyanide formation by UV disinfection is very limited at this time. The information hints that switching from chlorination to UV could reduce cyanide effluent levels, but much more investigation and full scale evaluation using very low detection limits would be needed to verify this preliminary hypothesis.

One study has shown that UV irradiation has the capability to decompose thiocyanate and create cyanide. Zheng et al. (2004a) conducted studies with thiocyanate-spiked wastewater treatment plant effluents and confirmed that cyanide does have the potential to form (12.3% conversion for irradiation time of 10 min at pH 6.9) when precursors are present (Zheng et al. 2004a). Emerging information indicates that UV disinfection may not create cyanide at the same concentrations created by chlorine disinfection.

While the research by Zheng et al. has indicated that exposure to high intensity ultraviolet light creates cyanide in wastewater effluent, recent pilot study work using collimated beam tests performed by the Los Angeles County Sanitation District on secondary effluents indicates that, at lower design intensities used in newer UV installations (e.g. 500 millilJoules per square centimeter), effluent cyanide concentrations may be relatively low (i.e. less than an analytical reporting limit of 5 ug/l). Full scale testing of UV disinfection to further assess cyanide formation is scheduled to occur at the Whittier Narrows Water Reclamation Plant in 2006 (LACSD, 2005).

Limited full scale data from two advanced secondary plants in the San Francisco Bay Region that utilize UV disinfection (Mountain View Sanitary District of Martinez [MVSD] and American Canyon) tend to support the finding that effluent cyanide concentrations less than 5 ug/l can be produced by plants utilizing UV disinfection. Mean and maximum total cyanide effluent concentrations from these facilities ranged from 0.5 to 1.4 ug/l and 3.0 to 5.0 ug/l, respectively (see Table 16). These results indicate that MVSD and American Canyon, both shallow water dischargers, could not comply with effluent limits derived from the NTR saltwater objectives of 1.0 ug/l (acute and chronic)(see Table 2), and may marginally comply with the effluent limits derived from the proposed saltwater site specific objectives of 2.9 ug/l chronic and 9.4 ug/l acute, without consideration for cyanide attenuation.

The above results suggest that a conversion from chlorination disinfection to UV disinfection provides a treatment technology option to reduce cyanide concentrations in effluent. However, the ability to provide reliable projections of effluent cyanide concentrations from UV disinfection is still uncertain, given the lack of full scale operating experience over a range of treatment facilities. Given the effluent quality observed in the San Francisco Bay Region for American Canyon and MVSD, the viability of this option to comply with effluent limits in the range from 2 to 4 ug/l for a broad spectrum of treatment facilities is uncertain.

6.2.3 Biosolids Incineration Operations

The practice of biosolids incineration is practiced in the San Francisco Bay Region by Central Contra Costa Sanitary District and the Palo Alto Regional Water Quality Control Plant. It has been determined that cyanide compounds are formed as a byproduct during the combustion of biosolids. These cyanide compounds have been shown to accumulate in scrubber water. When this water is discharged to the headworks of the treatment plant, an increase in influent cyanide is possible. Optimization of hearth furnace operations, specifically furnace oxygen levels and hearth exit temperatures have been shown to be able to reduce cyanide concentrations in scrubber water (Schmidt et al., 2000).

6.2.4 Nitrosation

Nitrosation of organic compounds, which involves the reaction with nitrite, NO_2^-, has been shown to produce CN^- under some conditions. The protonated form, HNO_2, has been shown to be the primary reactive species, with NO_2^- being almost non-reactive. This suggests that the potential for nitrosation to form cyanide in neutral to high pH wastewater effluent is negligible.

While nitrosation may not occur in the treatment process due to pH, the most commonly used total cyanide analytical method utilizes strong acidic conditions and high temperature, which greatly favors the nitrosation process. Procedures specified in the 20th edition of *Standard Methods* accounts for this potential through the addition of sulfamic acid in the sample preparation to remove nitrite. (Zheng et al., 2004d)

Reaction of nitrite species with organics to form cyanide may also occur during the distillation step of cyanide analyses. Sample pretreatment with sulfamic acid at the time of sampling, not at the time of analysis, has been recommended (Zheng et al., 2004d).

6.2.5 Nitrification

Incomplete nitrification (conversion of ammonia to nitrate) can result in excess nitrite in the wastewater effluent, leaving the potential for nitrosation to occur. It has been observed that cyanide formation occurs the most during the summer months when a plant is fully nitrifying

(Zheng et al., 2004b). Nitrate can also act as an oxidizing agent on thiocyanate, forming free cyanide.

6.2.6 Other Potential Mechanisms of Cyanide Formation

There is a possibility that ozonation can convert thiocyanate to cyanide under some conditions. Ozonation is not practiced by Bay area POTWs for disinfection of treated effluent.

6.3 Cyanide Pretreatment and Pollution Prevention Activities in San Francisco Bay Region

The proposed shallow water discharger policy of considering cyanide attenuation necessitates a review of the pretreatment and pollution prevention activities occurring regionally. According to the Basin Plan, exceptions to the zero-dilution policy for shallow water dischargers may be granted "on a pollutant-by-pollutant basis where an aggressive pretreatment and source control program is in place, including" completion of a source identification study, development and implementation of a source reduction plan, and commitment of resources to fully implement the source control and reduction plan. The Basin Plan also requires that NPDES permits for shallow water dischargers "shall include provisions requiring continuing efforts at source control, targeting the substances to which the exceptions apply." This section of the staff report describes regional efforts at source identification and control that shall continue as part of the Cyanide Action Plan that accompanies the revision of the marine cyanide objectives.

Bay Area POTWs, particularly shallow water dischargers, have conducted cyanide source identification and control efforts, some as a condition of having interim effluent limits. These activities have included source identification studies, industrial discharge assessments and evaluation of POTW treatment processes.

Source identification studies are conducted through collection system monitoring and business inspections. Sonoma County Water Agency (SCWA) provided an exemplary effort to identify cyanide influent sources. As required by its current NPDES permit for the Sonoma Valley County POTW, SCWA conducted a cyanide source identification study (SCWA, 2002). Commercial and residential collection system sites were monitored over a 6-month period in 1999. During that study, cyanide was never detected in the collection system above detection limits (i.e., 5 μg/L). Additional monitoring of residential collection system sites in 2001 also resulted in no detected values of cyanide. With no sources being identified through collection system monitoring, SCWA conducted a review of businesses to determine if there were any potential discharges of cyanide. As a result, four businesses were identified with cyanide levels above detection limits (a winery, two spas and a hospital). While none of these were determined to have significant mass discharges of cyanide, source control actions were implemented as appropriate. Specifically, the hospital was using a 1% cyanide solution in its laboratory that was being discharged to the sewer. SCWA staff worked with the hospital to identify a suitable non-cyanide replacement solution. The spas and winery each use chlorine for disinfection but, because of public health codes, there were no suitable replacement disinfectants.

Novato Sanitary District also conducted a Cyanide Source Reduction Study that included source identification and investigation of potential control strategies. Collection system monitoring and review of District records for industrial and commercial dischargers did not reveal any cyanide sources. Novato's service area is comprised entirely of residential and commercial users. Because no cyanide sources were identified, no source control actions were taken (Selfridge, 2002).

Cyanide discharges to sanitary sewer systems have been regulated at industrial facilities, primarily metal finishers, through Pretreatment Programs. Activities in San Jose and Palo Alto provide examples of industrial cyanide source control. In the late 1990s, the San Jose/Santa Clara Water Pollution Control Plant reduced its local discharge limit for cyanide. A fact sheet was developed and distributed to metal finishers and electroplaters in an effort to assist them with meeting the local limit. (San Jose, 1999). The Palo Alto Regional Water Quality Control Plant's Pretreatment Program regularly monitors electroplaters that utilize cyanide-containing plating baths. Palo Alto has worked with its industries to modify their processes to reduce discharges of both metals and cyanide to the sanitary sewer. This effort has included encouraging industries to install cyanide destruction treatment units, modification of rinse operations, and/or collection of concentrated cyanide wastes for offsite treatment (Palo Alto, 1996a; Palo Alto, 1996b). The cyanide destruction units use a two-stage alkaline chlorination treatment process. The first stage of treatment uses sodium hypochlorite to oxidize cyanide to cyanate, and the second stage further oxidizes the resulting cyanate to carbon dioxide and nitrogen (Cushnie, 1994). Palo Alto also identified a cyanide discharge from a solvent recycler and hazardous waste management facility. The facility had been accepting, processing and discharging a waste containing cyanide strongly complexed with iron (ferrocyanide). The discharge had led to violations of Palo Alto's cyanide discharge limits. Palo Alto worked with the facility to modify its procedures to prevent a recurrence of the discharge (Palo Alto, 1997).

Central Contra Costa Sanitary District (CCCSD), a deep water discharger, did not identify influent sources of cyanide but reviewed its treatment processes and determined that cyanide was being discharged in scrubber water from its sludge incineration process. CCCSD modified the air inlet configuration to reduce cyanide formation and evaluated redirecting the scrubber water. (CCCSD, 2002).

The above examples show how the Bay Area dischargers have conducted aggressive source control and pretreatment efforts on cyanide. In advance of this proposed Basin Plan amendment, several dischargers have conducted source identification studies, have developed and implemented specific source reduction plans, and have committed the necessary resources to fully implement the source control and reduction plans. These efforts have been successful at identifying and reducing cyanide sources in the collection system and within the treatment plant processes. Water Board staff believes that continuation of these programs will effectively minimize cyanide discharges to receiving waters, and that it is appropriate at this time to consider cyanide attenuation in receiving waters as part of effluent limits for shallow water dischargers. Appendix K provides an assessment of the compliance with Basin Plan and SIP requirements for the establishment of a mixing zone and dilution credit for shallow water dischargers to San Francisco Bay.

7 Project Description

7.1 Project Necessity and Definition

The proposed regulatory changes are listed in Section 2. The "project" is a proposed Basin Plan amendment that will do the following:

1) Establish site-specific marine water quality objectives for cyanide in San Francisco Bay Region;

2) Establish a shallow water discharger effluent limit policy for cyanide;

3) Establish required cyanide effluent limits for deep and shallow water dischargers to protect against degradation;

4) Define the implementation plan, maintain ambient concentrations of cyanide, and comply with state and federal antidegradation policies. The implementation plan consists of:

    a) Effluent concentration limits that will be protective of water quality in San Francisco Bay Region now and in the future;
    b) An influent monitoring program conducted by dischargers with industrial sources of cyanide to maintain surveillance of periodic influent spikes attributable to illegal discharges;
    c) An ambient water quality monitoring program to detect changes in ambient concentrations of cyanide in San Francisco Bay; and
    d) Cyanide Action Plan, consisting of standard permit provisions for all municipal dischargers to periodically update their source identification studies, develop and implement source reduction plans if warranted, and commit resources to fully implement the source control and reduction plan, at every permit reissuance (i.e., once per five years), and report to the Water Board.

As explained in Section 2, the proposed Basin Plan changes also include language to be added to clarify and reiterate required effluent limitations to implement copper and nickel site-specific objectives in South San Francisco Bay, south of the Dumbarton Bridge.

7.2 Cyanide Marine Site-Specific Objectives

As discussed in Sections 1 and 3, cyanide has become an NPDES permit compliance issue for municipal and industrial dischargers in the San Francisco Bay Region. NPDES permits issued to most dischargers to the Bay (e.g. Central Contra Costa Sanitary District, East Bay Municipal Utility District, Sewerage Authority of Southern Marin, City of San Mateo) have required individual permittees to submit work plans to the Water Boar d for the development of a site-specific marine water quality objective for cyanide in San Francisco Bay. A first step in this effort is to update the current U.S. EPA cyanide criteria to incorporate the most recent and scientifically defensible toxicity data.

The existing U.S. EPA cyanide marine criteria are heavily influenced by the toxicological data for one species (eastern rock crab – *Cancer irroratus*). Toxicity tests found *C. irroratus* to be six times more sensitive than the next most sensitive *Cancer* species tested. Data developed for the Puget Sound study in 1996 for four other west coast crab species (*Cancer* spp.) indicates that the sensitivity of these species is 24 times less than indicated by the 1981 *C. irroratus* data (Brix et al., 2000). Like Puget Sound, these four species are known to be present in marine and estuarine waters of the San Francisco Bay Region (Morris et al., 1980). Adding the four west coast crab species to the national data set and removing the *Cancer irroratus* data results in a recalculation of the cyanide marine chronic water quality criterion from 1 µg/L to 2.9 µg/L. Similar updated criteria have already been adopted by the State of Washington for parts of Puget Sound. The proposal is to adopt 2.9 µg/L as a 4-day average chronic objective and 9.4 µg /L as a 1-hour average acute objective, for the marine waters of the San Francisco Bay Region of California.

Based on an analysis of effluent data for the past several years, all deep water dischargers can comply with effluent limits derived from a cyanide chronic water quality objective of 2.9 µg/L, assuming a dilution credit of 10:1. However, none of the shallow water dischargers to the Bay can consistently comply with effluent limits derived from the proposed 2.9 µg/L objective. The resulting permit non-compliance would lead to a presumption that aquatic life uses are being impacted by existing shallow water discharges. In fact, available toxicity and biological information indicates that aquatic uses are not impacted by existing cyanide discharges (see Sections 7.3.3. and 7.3.4 and Appendix N). This information creates the need for a new policy for cyanide in shallow water discharges, described below.

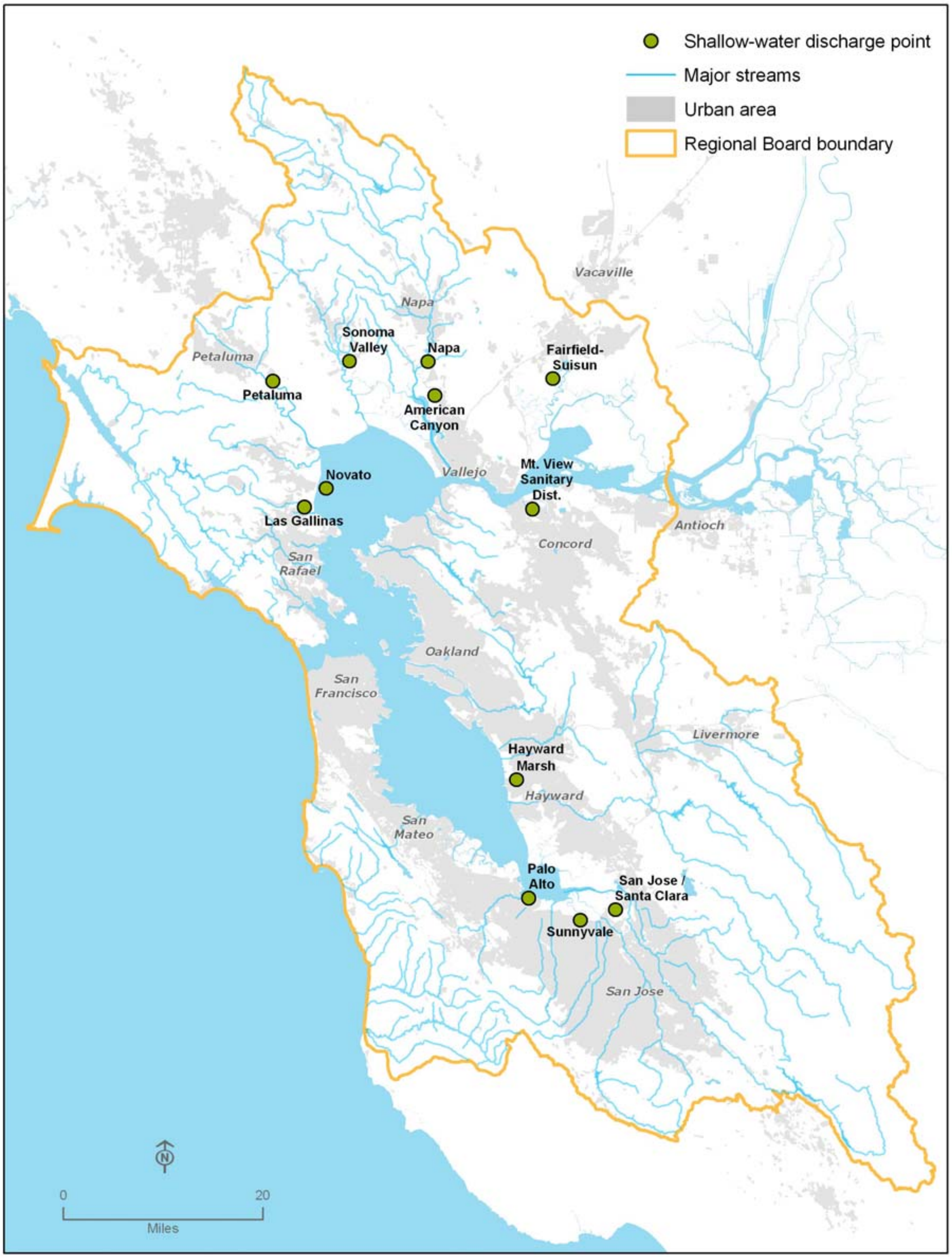
7.3 Cyanide Effluent Limitations Policy for Shallow Water Discharges

There are 12 dischargers to shallow waters for which the Board has not granted dilution credits in the calculation of effluent limitations (see Figure 3). Available effluent data from shallow water dischargers (Table 2) indicate that these dischargers will not be assured of achieving the SSO-based effluent limitation through reasonable treatment, source control and pollution prevention measures.

Unlike metals and selenium, cyanide is not a conservative pollutant and ambient data from the Regional Monitoring Program (RMP) indicate it does not threaten to accumulate to levels of concern in the waters and sediment of the Bay. Cyanide attenuates in the receiving waters due to degradation as well as dilution. Point source dischargers are the only significant source of cyanide to the Bay; urban runoff is not known to contain detectable levels of cyanide.

Before this project, no data existed in shallow water receiving waters (i.e., where discharges receive less than 10:1 dilution) on ambient levels of cyanide using available detection limits. In the last two years, information was collected by shallow water dischargers to better define attenuation of cyanide in areas of the region near their discharges, using a modified analytical method that lowered the detection limit. A body of low-level detection limit cyanide data was developed that exists nowhere else in the world. This information was used to develop an

Figure 3: Location of Shallow Water Dischargers



effluent limitations policy for shallow water dischargers that accounts for attenuation in receiving waters, described in Section 9.2. The foundation of this policy is using an attenuation factor (AF) that reflects degradation and dilution of cyanide in the receiving waters, and inserting the AF into the SIP dilution equation in place of the dilution factor (D) to calculate and require effluent limitations for all shallow water dischargers.

7.3.1 Methodology for Selection of Attenuation Factors and Derivation of Effluent Limits

The methodology employed for selection of attenuation factors is summarized below and is detailed in Appendix L.

The approach was to assess measured cyanide concentrations along the discharge gradients of the San Jose/Santa Clara Water Pollution Control Plant (San Jose) and other shallow water dischargers, to evaluate the selection of alternative, protective attenuation factor values on NPDES permit compliance, to estimate the areal extent of mixing zones associated with different attenuation factors, and to evaluate the potential for acute toxicity to passing organisms within mixing zones.

- *Assessment of empirical data along discharge gradients and available mathematical modeling*

  One year of monthly ambient data collected by San Jose along its discharge gradient in Artesian Slough and Coyote Creek was used to evaluate and establish the rapid attenuation of cyanide that occurs in the vicinity of shallow water discharges. Empirical data and mathematical modeling results from other shallow water discharges were used to confirm that the rapid attenuation of cyanide observed by San Jose was exhibited in other situations around the Bay. Attenuation curves were developed for a number of Shallow Water Discharges to determine attenuation factor values and the associated locations along each gradient where those values occur (see Appendix D). Two attenuation factor values (2.25 and 4.5), corresponding to successive receiving water stations along the San Jose gradient at Drawbridge and the mouth of Alviso Slough, were selected as upper and lower limit boundaries for further evaluation. These stations were selected because no exceedances of the proposed water quality objectives occurred in this portion of the receiving waters during the year-long study, therefore these values were considered protective. Additionally, these AF's would likely lead to effluent limits that could be complied with by municipal dischargers, based on effluent values attributable to contributions by disinfection processes.

- *Cyanide thresholds of concern in shallow water discharges; mixing zone issues*

  Not all available effluent data from 2000-2003 is considered to be acceptably protective. Effluent values above the EPA freshwater CMC (22 μg /L), equivalent to the LC0 for rainbow trout, and the marine site-specific final acute value (18.8 μg /L) derived from toxicity information for a copepod species, were considered too high to be reasonably in compliance or attributable to only disinfection. The analysis for attainability did not use compliance of all shallow water discharger data from 2000-2003 as the only criterion, but considered the freshwater CMC and recalculated marine site-specific FAV as well to prevent acute toxicity in the receiving waters of shallow water dischargers in the Region. Use of these values is considered appropriate because shallow water discharges are known to stratify in tidal sloughs for some periods of the day, and not mix immediately because of difference in salinity (1 part per thousand) from receiving waters (anywhere from 0 to 34 ppt). Also, many shallow water discharges compose 100% of the waters in certain sloughs at lower low tide and truly receive practically "zero dilution" over a short timescale exceeding one hour (e.g., including but not limited to Novato discharge on the San Pablo Bay mudflat and Palo Alto discharge in constructed dead-end slough and South Bay mudflat).

- *Analysis of projected NPDES permit compliance for alternative attenuation factor values*

  An iterative evaluation of potential AF's, based on actual effluent data between 2000 and 2003, was conducted to arrive at the preferred AF. These evaluations included AF's of 2.25, 3.0, 3.5, and 4.5.

  The selected attenuation factor values were evaluated to determine the projected compliance of each shallow water discharger with final cyanide effluent limits derived from the proposed cyanide marine SSO for the San Francisco Bay Region, based on the procedure described above and in Appendix F. The results of this analysis are summarized in Table 16. At an attenuation factor value of 2.25, Fairfield Suisun, Hayward Marsh, Las Gallinas Valley SD, Napa, Petaluma, Sonoma County Water Agency and Sunnyvale would be anticipated to have compliance difficulties with projected effluent limits. At an attenuation factor value of 4.5, no shallow water dischargers would have attainability issues. Fairfield-Suisun and Sunnyvale had samples above potential limits based on 4.5, but those effluent values exceed the freshwater CMC and marine FAV and would therefore be considered too high for compliance that is protective of receiving waters in a shallow water discharge situation where stratification of effluent occurs. Attenuation factors of 3.0 and 3.5 were also investigated for potential compliance difficulties. Aside from Fairfield-Suisun and Sunnyvale, Napa, Petaluma, and Sonoma would all have compliance difficulties with a 3.0 attenuation factor, whereas all three of them would be expected to attain effluent limits with a 3.5 attenuation factor. The 3.5 attenuation factor would establish more protective effluent limits than the 4.5 attenuation factor while still providing POTWs with attainable effluent limits for discharges attributable to in-plant formations of cyanide. For these reasons, 3.5 is the recommended attenuation factor to use for derivation of POTW effluent concentration limits (see Appendix F).

- *Analysis of the areal extent of mixing zones associated with different attenuation factor values*

  Using the attenuation factor curves developed in the first step, the distance from the point of discharge was determined for each discharge for the two boundary attenuation factor values (2.25 and 4.5). Subsequently, areal estimates of the surface water between the point of discharge and the point where a given attenuation factor value would occur were determined. These distances and areal estimates are summarized in Appendices D and L.

- *Evaluation of potential for Acute Toxicity in mixing zones*

  A review of available toxicity data for sensitive aquatic organisms was performed to evaluate whether acutely toxic conditions to mobile organisms would occur within either of the mixing zones associated with the two different attenuation factor values. The review indicated that acute toxicity would not significantly impact the determination regarding the selection of appropriate attenuation factors for the shallow water dischargers.

- *Recommended Attenuation Factor for Shallow Water Dilution Credit*

  Based on the completion of the above steps in the analysis, the decision was reached to use an attenuation factor of 3.5, substituted in the SIP equation for the dilution factor (D), to establish effluent limits for each of the shallow water dischargers. Selection of this value and implementation of resulting effluent limits would not significantly impact ambient cyanide concentrations in the Bay, which currently comply with the proposed cyanide SSOs.

Table 16: Cyanide Attenuation Factor Attainability Summary

Discharger		1 American Canyon	2 Fairfield-Suisun	3 Hayward Marsh Effluent	4 Las Gallinas	5 Mt. View	6 Napa	7 Novato	8 Palo Alto	9 Petaluma	10 San Jose/Santa Clara	11 Sonoma	12 Sunnyvale
Coefficient of Variation (CV)	CV-regression	0.493	1.002	0.794	0.776	0.600	1.227	0.665	0.300	0.868	0.423	0.858	0.944
	CV-half detection limit	0.263	0.979	0.764	0.730	0.600	1.095	0.568	0.564	0.731	0.423	0.822	0.903
Summary Statistics	**MEC**	**2.9**	**28**	**11.3**	**10**	**1.6**	**20**	**4.43**	**5**	**10**	**8**	**13**	**29**
	Mean	**1.4**	**3.9**	**2.9**	**3.0**	**0.5**	**2.6**	**1.8**	**3.3**	**2.9**	**2.8**	**3.2**	**4.4**
	95th	**2.5**	**11.7**	**7.3**	**7.8**	**1.3**	**8.3**	**4.6**	**5.1**	**9.1**	**4.9**	**8.7**	**12.3**
	99th	**3.4**	**21.1**	**11.8**	**12.9**	**2.2**	**16.4**	**7.6**	**6.3**	**17.1**	**6.3**	**14.9**	**21.4**
	99.87th	**4.6**	**38.0**	**19.1**	**21.3**	**3.7**	**32.3**	**12.3**	**7.6**	**32.1**	**8.1**	**25.4**	**37.1**
Attenuation Factor (AF)=2.25	LTA	5.2	3.2	3.8	3.8	4.5	2.8	4.2	6.3	3.5	5.5	3.6	3.4
	AMEL	7.6	6.2	6.6	6.6	7.0	6.1	6.8	7.9	6.4	7.6	6.4	6.4
	MDEL	13.9	15.6	15.0	14.9	14.0	16.6	14.4	11.9	15.3	13.0	15.2	15.9
	Compliance	Yes	**No,** Mean>LTA, 95th>AMEL, 99th>MDEL	**No,** Mean>LTA	**No,** 95th>AMEL	Yes	**No,** 95th>AMEL	Yes	Yes	**No,** 95th>AMEL, 99th>MDEL	Yes	**No,** 95th>AMEL	**No,** Mean>LTA, 95th>AMEL, 99th>MDEL
AF=3.0	LTA	6.4	3.9	4.6	4.7	5.5	3.5	5.2	7.6	4.3	6.7	4.4	4.2
	AMEL	9.3	7.5	8.0	8.1	8.5	7.5	8.3	9.7	7.8	9.3	7.9	7.9
	MDEL	17.0	19.0	18.3	18.2	17.1	20.3	17.6	14.5	18.6	15.9	18.6	19.4
	Compliance	Yes	**No,** 95th>AMEL, 99th>MDEL	Yes	Yes	Yes	**No,** 95th>AMEL	Yes	Yes	**No,** 95th>AMEL	Yes	**No,** 95th>AMEL	**No,** Mean>LTA, 95th>AMEL, 99th>MDEL
AF=3.5	LTA	7.2	4.3	5.1	5.2	6.1	3.9	5.8	8.6	4.8	7.5	4.9	4.7
	AMEL	10.4	8.4	9.0	9.0	9.5	8.4	9.3	10.8	8.8	10.4	8.8	8.8
	MDEL	19.1	21.3	20.5	20.4	19.1	22.8	19.7	16.3	20.9	17.8	20.8	21.8
	Compliance	Yes	**No,** 95th>AMEL	Yes	Yes	Yes	Yes	Yes	Yes	**No,** 95th>AMEL	Yes	Yes	**No,** 95th>AMEL
AF=4.5	LTA	8.8	5.3	6.3	6.4	7.5	4.7	7.0	10.4	5.9	9.2	5.9	5.7
	AMEL	12.7	10.3	10.9	11.0	11.6	10.2	11.3	13.2	10.7	12.7	10.7	10.8
	MDEL	23.3	25.9	24.9	24.8	23.2	27.8	23.9	19.8	25.3	21.7	25.3	26.5
	Compliance	Yes	**No,** 95th>AMEL	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**No,** 95th>AMEL
Note:	Coefficient of variation (CV) were calculated using both half detection limit method and probability regression method, and are listed in the first two rows of the table for comparison. The AMELs and MDELs were calculated using the CVs from the probability regression method. In general, the higher the CV, the higher the MDEL, but the lower the AMEL. LTA = Long Term Average discharge condition, MEC = Mean Effluent Concentration (observed maximum pollutant concentration for the effluent) The above effluent limits were calculated using SIP procedures, where an attenuation factor (AF) is substituted for the dilution factor (D).												

7.3.2 Spatial Extent of Mixing Zones

The selection of attenuation factors for the determination of water quality-based effluent limits involves the establishment of a cyanide attenuation zone (essentially a mixing zone as described in the SIP). Compliance with cyanide water quality objectives occurs at the edge of the cyanide attenuation zone (the location in the receiving water where the ratio of effluent to receiving water concentrations of cyanide equals the attenuation factor). The SIP requires that the size of mixing zones be no larger than necessary to provide intended permit relief; for this analysis, it is presumed that the same requirement applies to the proposed cyanide attenuation zone.

Appendix K provides an assessment of the compliance with Basin Plan and SIP requirements for the establishment of a mixing zone and dilution credit for shallow water dischargers to San Francisco Bay. This assessment and Section 6.3 are provided to document the fulfillment of these requirements.

The geometry of the cyanide attenuation zone for each shallow water discharger is site-specific and in part a function of the selected attenuation factor. Estimates of the distance from the point of discharge to the edge of the cyanide attenuation zone and the surface area of the cyanide attenuation zone for each SWD is provided in Appendix D. The upper and lower bounds of potential attenuation factors (2.25 and 4.5) are represented to demonstrate the minimum and maximum dimensions of potential cyanide attenuation zones. The edges of the cyanide attenuation zones were determined using measured cyanide concentrations along individual discharge gradients and results from mathematical water quality modeling studies, where available.

7.3.3 Consideration of Acute Toxicity to Sensitive Organisms in Mixing Zone

In the establishment of mixing zones, the SIP prohibits acutely toxic conditions, i.e. lethality to mobile organisms that move or drift through the mixing zone.

Concentrations of free cyanide that have been observed to exhibit acute toxicity to sensitive saltwater and freshwater species are shown below. The values shown as LC50 are the free cyanide concentrations that were observed to be lethal to 50 percent of the most sensitive test organisms, in the freshwater and recalculated saltwater databases. The LC0 values are concentrations estimated to produce no acute toxicity to any test organisms.

Acartia clausi copepod (saltwater)	LC50 =	30 µg/L (unmeasured)
	LC0 =	15 µg/L (estimated)
Rainbow trout (juvenile) (freshwater)	LC50 =	44.7 µg/L (measured)
	LC0 =	22.4 µg/L (estimated)

Depending on the specific discharge, these specific species could pass through the cyanide attenuation zones of the shallow water dischargers to San Francisco Bay waters. Some of the shallow water discharges occur in dead end sloughs as described in Table 17, where occurrence may be more rare. Downstream movement of mobile aquatic organisms may occur in Coyote Creek, Guadalupe Slough, Sonoma Creek (connected to Schell Slough), Petaluma and Napa Rivers, and Miller Creek, a regionally important steelhead-supporting stream. Exposure of organisms on the mudflat near the Novato mixing zone will be very short duration and will not produce concentrations that would produce acute toxicity to sensitive organisms.

Table 17: Effluent discharge areas for shallow water dischargers

Shallow Water Discharger	Receiving Water	Description
San Jose	Artesian Slough	Dead-end slough
	Coyote Creek	Major tributary
Sunnyvale	Guadalupe Slough	Minor tributary
Palo Alto	Unnamed channel	Dead-end slough
Las Gallinas	Miller Creek	Minor tributary
Mt. View	Pacheco Slough	Dead-end slough
Novato	San Pablo Bay	Mud flat
Sonoma County Water Agency	Schell Slough	Dead-end slough
Petaluma	Petaluma River	Minor Tributary
Napa	Napa River	Major tributary
American Canyon	North Slough	Wetlands
Hayward Marsh	Hayward Shoreline Regional Park marsh basin	Dead-end slough
Fairfield Suisun	Boynton Slough	Dead-end slough

Free cyanide concentrations in the estimated range from 15 to 22 µg/L form the upper bound of cyanide concentrations that would cause acute toxicity within a cyanide attenuation zone. In the U.S. EPA criteria, total cyanide concentrations are used as a conservative estimate of free cyanide levels. Therefore, maximum daily total cyanide concentrations ranging from 15 to 22 µg/L would ensure (with a significant margin of safety) that acute toxicity to sensitive organisms would not occur within any of the cyanide attenuation zones of shallow water dischargers.

7.3.4 Evaluation of Biological Community along a Representative Shallow Water Discharge Gradient

Available information suggests that cyanide concentrations in existing shallow water discharges are not measurably affecting biota in the receiving waters, and therefore the proposed policy would be protective of the potentially affected beneficial uses. A case in point is the Palo Alto Regional Water Quality Control Plant (Palo Alto), which has an arguably "worst-case" source scenario of documented industrial sources of cyanide in the influent and associated historic effluent violations, as well as in-plant sources of both biosolids incinerator scrubber water and disinfection by chlorination. Palo Alto commissioned a biological study of its effluent discharge channel in August 1997. A November 1997 technical report summarizes the results of the study, titled *Benthos and Fisheries Assessment, Palo Alto Wastewater Treatment Plant Discharge Channel*. The study also examined biological conditions in San Francisquito Creek, an urban creek with a fairly large, undeveloped watershed located 1000 feet northwest of the discharge channel. The results of the August 1997 biological assessment of benthic community and fish in the Palo Alto effluent channel indicated that it supported a diverse assemblage of aquatic fauna. The types and abundances of organisms present in the channel were representative of typical South Bay slough species and not indicative of highly stressed benthic communities, and not degraded relative to the tidal channel of San Francisquito Creek. These conditions exist despite levels of cyanide in the Palo Alto effluent channel that are elevated, at times, in comparison to the NTR cyanide objective of 1.0 ug/l and the proposed chronic site specific objective of 2.9 ug/l.

A description of the Palo Alto study and results is presented in Appendix N.

7.3.5 Options explored to resolve shallow water discharger compliance issues

Several alternatives were evaluated to seek resolution of shallow water discharger permit compliance issues for cyanide. These alternatives included the following:

- Water Effect Ratio (WER)
- Toxicity testing of effluent
- Toxicity testing of ambient waters
- Use of a “translator” approach based on measurements of free cyanide and total cyanide

The WER approach was evaluated by the City of San Jose in a pilot-testing program performed in 2002 using larvae of a sensitive fish species, *Menidia beryllina* (Inland silversides), as the test organism. The City conducted acute toxicity tests in accordance with U.S. EPA guidance for performing water effect ratio studies but found that the sensitivity of the test organism (LC50 of 87 μg/L in laboratory water) was not sufficient to derive a WER value that was (a) applicable to the cyanide concentrations measured in effluent (typically in the range from 1 to 10 μg/L) and (b) a value significantly different from 1.0 (observed WER was 0.92)(City of San Jose, 2002). Therefore, the WER approach was determined not to be a useful approach to address the shallow water discharger compliance issues.

Direct measurement of cyanide toxicity in effluent and receiving waters was considered as a potential method to address the shallow water discharger cyanide compliance issues. Upon examination of sensitive aquatic organisms, it was determined that even the most sensitive saltwater test organism, a copepod (*Acartia clausi*), was not adequately sensitive (LC50 = 30 μg/L) to confirm or deny cyanide toxicity in either effluent (cyanide concentrations of 1 to 10 µg/L), shallow discharge receiving waters (cyanide concentrations of 0.3 in background waters to less than 3 µg/L in sloughs near outfalls). Similar evaluation of the use of the most sensitive freshwater test organism, rainbow trout (*Oncorhynchus mykiss*) with an LC50 of 44.7 µg/L produced a similar finding.

A "translator" approach was considered which would use measured concentrations of free cyanide and total cyanide in effluent and/or ambient waters to determine the ratio in each water. This approach is similar to trace metal translators in which dissolved metal measurements and total recoverable metals measurements are used to develop ratios used in the derivation of effluent limitations. The challenge in the derivation of the free to total cyanide ratios is in the availability of analytical methods to measure these cyanide fractions at the levels present in effluent or ambient waters. Analytical methods for total cyanide were researched and methods were found that would lower the detection limit from the levels obtained using U.S. EPA standard methods (3 to 5 µg/L) to 0.1 to 0.3 µg/L in ambient waters and 1 µg/L in effluent (Exygen Research, 2002; City of San Jose, 2004). However, similar analytical methods do not exist for the determination of free cyanide concentrations (Exygen, 2002). Therefore, the inability to measure free cyanide concentrations at levels that total cyanide is present in ambient waters (i.e. in the range from zero to 0.4 µg/L) prevents the derivation of the desired translator values and precludes the use of this approach in the derivation of effluent limits for cyanide.

The above approaches are consistent with the evaluation of permit relief options as stipulated in Step 6 of the decision tree of Appendix 5 of the SIP. Appendix 5 of the SIP outlines a decision-making approach for performance and approval of a variety of special studies by the State and Regional Boards, including the development of site-specific objectives.

The proposed action is the Water Board adoption of the BPA as provided in underline-strikeout format in Appendix A of this report, exercising the regulatory options of the site-specific objective and an attenuation-based mixing zone policy for shallow water dischargers specifically for the pollutant cyanide.

7.4 Justification of the Site-Specific Objectives Required by SIP

Water quality-based effluent limitations for shallow water and deep water dischargers are calculated according to the methodology in the "Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California (SIP)." Section 5.2 of the SIP requires that a demonstration be made that a site-specific objective is needed to modify an existing water quality objective to remedy significant regulatory impacts for NPDES permittees.

Section 3.4 explains that significant compliance problems will occur throughout the San Francisco Bay Region for the majority of NPDES dischargers if effluent limits based on the existing NTR standard of 1.0 µg/L are adopted in NPDES permits. This analysis addresses one of the prerequisites for consideration of the proposed cyanide SSO as outlined in Section 5.2 of the SIP. The scientific merit for the proposed cyanide SSO has been previously described in Section 4.

8 Analysis of Issues and Alternatives for Proposed Amendment

The proposed amendment to the Basin Plan consists of changes involving establishing site-specific water quality objectives for cyanide for the San Francisco Bay Region along with a shallow water discharger effluent limit policy to achieve and maintain the site-specific objectives.

8.1 State Peer Review Requirements

Basin Plan amendments establishing new water quality objectives and related requirements require scientific peer review. Health and Safety Code, Sect. 57004 requires an external peer review for work products that constitute the scientific basis for a rule "…establishing a regulatory level, standard, or other requirement for the protection of public health or the environment." State law (SB 1320) defines "scientific basis" as "the foundations of a rule that are premised upon, or derived from empirical data or other scientific findings, conclusions, or assumptions establishing a regulatory level, standard or other requirement for the protection of public health or the environment." Under SB 1320, "rule" includes any policy adopted by the State Water Resources Control Board under the Porter-Cologne Water Quality Control Act (Division 7, commencing with Section 13000 of the Water Code) that has the effect of a regulation.

This amendment proposes new regulations, as it substitutes site-specific water quality objectives for cyanide for protection of marine and estuarine aquatic life uses for existing federal criteria in the NTR. It also establishes new procedures for the determination of water quality based effluent limitations for shallow water dischargers, mandates cyanide limits for all deep water dischargers, and reiterates required effluent limitations for copper and nickel south of Dumbarton Bridge.

The technical basis of the amendment is subject to external scientific peer review. The comments from the peer reviewers concerning the technical basis of this BPA are provided in Appendix G along with responses to those comments.

8.2 Consideration of alternatives for the proposed amendment

Two alternatives are considered to the proposed amendment: site-specific objective only, and no action. The first would adopt the site-specific objective without any specific effluent limitation policy for cyanide. As such, the procedures of the SIP would determine whether effluent limits would be required based on the reasonable potential analysis procedure, and then the dilution factor assigned based on deep and shallow dischargers, as defined in the Basin Plan. As shown in this report, the shallow water dischargers would be unable to consistently meet 2.9 ug/L as an effluent limit and this alternative would result in chronic noncompliance with effluent limits for the 12 shallow water dischargers. Some deep water dischargers would not receive limits whereas the proposed amendment includes required effluent limitations for all municipal dischargers.

The other alternative to adopting the proposed BPA is "no action," not adopting the proposed BPA and proceeding with the development of individual effluent limits based on end-of-pipe compliance with the existing NTR objective for shallow water dischargers, and a 10 ug/L limit for deep water dischargers. As shown in Section 3.4, widespread noncompliance would result.

Implementation of the proposed BPA would not result in significant environmental impacts and would establish effluent limits that provide reasonable protection of sensitive beneficial uses and avoid unnecessary and unwarranted NPDES permit compliance problems. Therefore, the proposed BPA is the favored course of action. A no action alternative would allow unnecessarily stringent and scientifically indefensible effluent limits to replace interim limits for dischargers and thereby require the imposition of mandatory minimum penalties and other enforcement actions. Additionally, dischargers would be forced to consider implementing economically infeasible measures to comply as the only alternative to mandatory penalties (see Section 10.3) and continued enforcement. If only the site-specific objective is adopted, then most or all of the 12 shallow water dischargers will experience widespread noncompliance. The proposed BPA is the preferred alternative. Alternatives are further discussed in Section 10.2.

9 Implementation Plan

The Basin Plan amendment implementation plan was developed to serve as a non-degradation plan to ensure that existing water quality is maintained, beneficial uses are protected, and exceedances of the site-specific water quality objectives do not occur in marine and estuarine waters of the San Francisco Bay Region.

9.1 Effluent Limitations Justification

Required effluent limitations are proposed for most dischargers in the San Francisco Bay Region, to fulfill antidegradation requirements and ensure full commitment of resources from dischargers to maintain current performance and pollution prevention, as required by the Basin Plan (see Appendix K). Cyanide has been detected in effluents of most of the dischargers in the region. For some dischargers that have not detected cyanide in the effluent, the method detection limit is too high (e.g., 10 ug/L) to make a determination that cyanide is not present. Most of the detected values are thought to be a by-product of disinfection processes, including industrial dischargers to the San Francisco Bay that disinfect their effluent or sewage inputs to their wastewater. Cyanide levels in effluent appear fairly consistent region-wide, with 90% of 2,349 values ranging from 1 to 10 ug/L, along with episodic spikes attributable to dumping events in collection systems or other seasonal anomalies.

A few of the dischargers in the region have effluent values above 20 ug/L, and because of known cyanide users in the collection system, disinfection processes alone may not explain the higher effluent values.

The SIP provides guidance to Regional Water Boards on determining which priority pollutants require effluent limitations. Step 7 of Section 1.3 of the SIP provides that Water Boards may find that effluent limitations are required for pollutants even if Steps 1 through 6 do not trigger the requirement.

Most dischargers monitor effluent cyanide as grab samples once per month, hardly able to catch every potential pulse of cyanide that could be dumped into the collection system. Therefore only using Steps 1 through 6 of Section 1.3 of the SIP bases a determination for need for effluent limits on mere snapshots of effluent quality. Given the episodic nature of cyanide in effluent, and the receiving waters' vulnerability to illicit discharges to the collection system, more accountability is needed than the traditional reasonable potential procedure in Steps 1 through 6 to ensure that water quality standards for the toxic pollutant cyanide are not violated once per three years.

Recent experience has demonstrated how any municipal discharger in the region with cyanide sources to the influent has a reasonable potential to contribute to exceedance of the water quality standard (objective), whether it is 1.0 or 2.9 ug/l. In 2004, while the City of San Jose was performing its study of cyanide attenuation in the Bay, pulses of high concentrations of cyanide were tracked through the treatment plant and into the Bay on three separate occasions (in the months of May, November and December). In the case of May 2004, concentrations of cyanide in Artesian Slough, where the standard is currently 1.0 ug/l and proposed to be 2.9 ug/l, were measured at 62 ug/l near the outfall to under 10 ug/l at Coyote Creek, almost 4 miles from the outfall (see Figure 3 of Appendix L for graphic description). With the LC50 of cyanide at 44 ug/L for rainbow trout, adverse effects to aquatic life during these dumping events were likely. Eventually, San Jose source control staff identified a single industrial source of these cyanide-dumping events. This case study shows that a single entity in the collection system of a large advanced secondary treatment plant can cause serious water quality standard violations of cyanide in the Bay.

Before work began on this proposed Basin Plan amendment, very little was known about cyanide levels in the areas of the San Francisco Bay Estuary near discharge points or in the deeper channels. It was assumed, because of non-detect data, that cyanide did not approach thresholds of concern (i.e., chronic water quality objectives). Lower detection limits, advanced by the San Jose laboratory (explained in Appendix M), have shed light on ambient cyanide characteristics, particularly near shallow outfalls (n=225, see Appendix L). While typically protective of aquatic life, levels very close to shallow water discharge outfalls have been shown to exceed thresholds of concern, forcing the consideration of mixing zones (i.e., cyanide attenuation zones) described in Appendices B, D, and L, and in Sections 7.3 and 9.2.1.

The proposed cyanide marine site-specific objective will be implemented through heretofore required effluent limitations for most of the NPDES point source dischargers in the San Francisco Bay Region. This is because cyanide in deep water and shallow water dischargers' effluents, attributable to disinfection processes, incineration processes, or contributions to the collection systems, have a reasonable potential to cause or contribute to an exceedance of the numeric level of 2.9 ug/l cyanide in the San Francisco Estuary. Levels in the main estuary have been measured at 0.5 ug/l cyanide. The 99^{th} percentile value of effluent concentration from all the effluent data from all dischargers in this Region (from 2000-2003, n=2,349) is 26 ug/l. Discharges at this level would lead to measurable receiving water cyanide levels above 2.9 ug/l in most instances, and therefore an equitable, attainable, and enforceable effluent limitation policy is proposed to keep all dischargers vigilant and maintaining effluent cyanide levels at current performance or better. This approach will ensure adherence to applicable state and federal antidegradation policies.

9.1.1 Deep Water Municipal Dischargers

Water quality-based effluent limitations for cyanide will be required for all deep water municipal dischargers. Upon full approval of this proposed Basin Plan amendment, limits will be derived using the default 10:1 dilution ratio in accordance with procedures described in Section 1.4 of the SIP. If the Board's dilution policy is changed in the future, limits will be derived in accordance with that policy.

9.1.2 Deep Water Industrial Dischargers

Water quality-based effluent limitations for cyanide will be required for all deep water industrial dischargers. Upon full approval of this proposed Basin Plan amendment, limits will be derived using the default 10:1 dilution ratio in accordance with procedures described in Section 1.4 of the SIP. If the Board's dilution policy is changed in the future, limits will be derived in accordance with that policy. For those deep water industrial dischargers that do not detect cyanide in the effluent with a method detection limit of 1.0 µg/L or less, and document that they do not use cyanide in their industrial process and do not disinfect, no cyanide limits will be required.

9.2 Effluent Limitations for Shallow Water Dischargers

Under the current zero-dilution policy for shallow water dischargers, none of the 12 shallow water dischargers are able to comply with effluent limitations derived from the proposed site-specific objective unless some recognition of the attenuation of cyanide is incorporated into the derivation of effluent limitations. Available effluent data, summarized in Table 2 indicates that none of these dischargers could reliably meet 2.9 µg/L as an average monthly limit.

Considering that effluent cyanide levels are mostly controlled by disinfection processes that protect receiving waters for recreational beneficial uses, and that ambient levels near discharges meet the proposed site-specific objective which is considered protective of aquatic life beneficial uses, Water Board staff propose that it is appropriate to consider the rapid attenuation in cyanide levels that occurs in the Bay in the determination of effluent limits for shallow water dischargers.

To help protect against degradation of waters associated with adopting a less stringent standard, and recognizing that the only areas of the San Francisco Bay Region with ambient values near the proposed SSO are near point source discharge outfalls, effluent limitations for cyanide are proposed to be required for all shallow and deep water municipal dischargers and most deep water industrial dischargers.

9.2.1 Shallow Water Cyanide Attenuation Factor (AF)

To incorporate cyanide attenuation into derivation of effluent limitations, a cyanide attenuation factor (AF) is proposed. To derive numeric effluent limitations for shallow water dischargers, the dilution equation of the SIP is used but the dilution credit (D) is substituted with the AF. One AF is proposed for all shallow water dischargers, based on review of data from shallow water discharger areas around the region. See Section 7.3.1 for a description of the methodology used for attenuation factor selection. Also, refer to Appendix L for a detailed description of the derivation of attenuation factors for the San Jose/Santa Clara WPCP and other shallow water discharges, and Appendix D for maps of the proposed cyanide attenuation zones.

A number of shallow water dischargers have performed water quality modeling studies to assess the patterns and time scales of dilution of treated effluent in the San Francisco Bay Estuary (see Appendix E). These studies have typically been calibrated using dye studies or studies using other tracers. Information derived from those modeling studies provides important information for estimation of cyanide attenuation near a given discharge. A summary of these modeling studies is provided in Appendix E.

Other shallow water dischargers have performed monitoring of cyanide levels along a gradient from the discharge location using low detection limit analytical methods pioneered by the City of San Jose. A brief description of the modified Standard Method 4500-CN developed and used by San Jose is included in Appendix M. Analysis of effluent and ambient data provides an empirical measure of cyanide attenuation along discharge gradients. A summary of these ambient data near shallow water discharges to the Bay is provided in Appendix B of this report.

The use of measured concentrations in the Bay provides information for direct calculation of attenuation factors, and thereafter water quality-based effluent limits. Using ambient data, attenuation factors are calculated as the reciprocal of the total cyanide observed at a given sampling station measured as a fraction of the total cyanide discharged by a treatment facility at the upper end of a discharge gradient. Available modeling results can be used to give a conservative estimate of an attenuation factor at a given location, based on the dilution of effluent at a given location without account for degradation of total cyanide in the Bay.

The conceptual formula for attenuation is as follows:

***Attenuation* = [*(Degradation in ambient waters) + (Effluent Dilution)*]**

When using empirical cyanide data, the calculation of an attenuation factor inherently takes both degradation and dilution into account. Given the log normal distribution of such empirical data, median values are used in this calculation. The attenuation factor derived from empirical cyanide data is calculated as follows:

***AF* = [*1/(Ratio of total cyanide at a given location to the total cyanide in the effluent discharge)*]**

When using modeling results that provide information on the percent of effluent at given locations, the calculation of an attenuation factor does not take degradation into account. The attenuation factor derived from modeling results is calculated as follows and only takes dilution effects into account:

***AF* = [*1/(Percent effluent at a given location)*]**

Appendices B, D and L provide a summary of the attenuation factor evaluation that has been performed for specific shallow water dischargers to the Bay based on available information. Appendix F describes the attainability analysis that accompanied the receiving water evaluation and that led to selection of a single value AF proposed to be applied region-wide, shown in the following table, serving as the basis for NPDES permitting determinations.

An evaluation of attainability of hypothetical limits, described in Appendix F, suggests that 3.5 is the appropriate AF that will ensure compliance based on disinfection-related cyanide levels in effluent, while being protective of beneficial uses.

Water quality-based effluent limits have been derived for individual shallow water dischargers using an AF of 3.5 described in Table 18 and the effluent limit derivation procedures described in the SIP[1].

[1] Cyanide is often not detected in effluent using U.S. EPA-approved methods; In evaluating attainability with respect to effluent limits, various methods are used to quantify non-detect results. The Half-Detection Method used in the SIP substitutes every non-detect value with a value that is one-half the detection limit. The probability regression method was also used to evaluate attainability with respect to effluent limits, and final values were not significantly different to that of the SIP method .

Table 18: Water Quality-based Effluent Limits for Shallow Water Dischargers Based on Proposed Attenuation Factors

Discharger	Discharge Location	AF	AMEL (μg/L)	MDEL (μg/L)
American Canyon	North Slough	3.5	10.4	19.1
Fairfield-Suisun	Boynton Slough/Suisun Slough	3.5	8.4	21.3
Hayward Marsh	Hayward Shoreline Regional Park marsh basin	3.5	9.0	20.5
Las Gallinas	Miller Creek	3.5	9.0	20.4
Mt. View SD	Pacheco Slough	3.5	9.5	19.1
Napa SD	Napa River	3.5	8.4	22.8
Novato SD	San Pablo Bay	3.5	9.3	19.7
City of Palo Alto	Unnamed channel/South Bay	3.5	10.8	16.3
City of Petaluma	Petaluma River	3.5	8.8	20.9
City of San Jose	Artesian Slough/Coyote Creek	3.5	10.4	17.8
Sonoma County Water Agency	Shell Slough	3.5	8.8	20.8
City of Sunnyvale	Guadalupe Slough	3.5	8.8	21.8

These effluent limits will ensure compliance with the proposed site-specific acute and chronic objectives at the edge of the attenuation zone. The distances from the individual points of discharge to the edge of the attenuation zone are shown in Appendices D and L.

9.3 Cyanide Action Plan

The following describes the proposed plan for actions to ensure that current discharger performance is maintained under the proposed BPA, and to ensure compliance with state and federal antidegradation policies. Additionally, the Basin Plan requires that NPDES permits for shallow water dischargers “shall include provisions requiring continuing efforts at source control, targeting the substances to which the exceptions [to the zero-dilution effluent limitation policy] apply.” Because an attenuation factor is proposed for calculation of shallow water discharger effluent limits to be required in their NPDES permits, commitment to continuing efforts at cyanide source control by these dischargers is mandatory.

Required Effluent Limitations for Cyanide

With the exception of deep water industrial dischargers that do not use cyanide in their processes, do not disinfect, and have no detectable cyanide in their effluent, all estuarine and marine dischargers in the region will have water quality-based effluent limitations in their permits to implement the site-specific objective. An attainability analysis, included as Appendix F, demonstrates that shallow water dischargers can readily comply with limits based on an attenuation factor of 3.5, and deep water dischargers are expected to be able to comply with limits based on a minimum dilution ration of 10:1, which is the default dilution ratio used in NPDES permits at the time of the writing of this report. This ratio may change in the future based on modifications to the Basin Plan dilution policy, if so ordered by the Water Board. The mechanism of required effluent limits will ensure that current performance is maintained, and sources of cyanide to the influent are tracked and regulated by the dischargers.

Monitoring and Surveillance requirements

An element of the action to adopt site-specific cyanide objectives and shallow water discharger effluent limitations is a program of monitoring and surveillance to prevent unnecessary or excessive discharges of cyanide from point source discharges to the Bay. This program is described below:

- *Influent and Effluent*

  Monitor total cyanide monthly in influents and effluents using low detection level cyanide analytical methods. As noted in Appendix F, cyanide attainability analysis, some dischargers with higher effluent cyanide values in the past few years should sample effluent more than once per month for compliance purposes.

- *Ambient*

  Add cyanide monitoring to the regular RMP sampling program for the Bay. Use analytical methods with detection limits equivalent or better than those used in the 13267 monitoring performed by CCCSD for SFEI. Implement an ambient trigger concentration of 1.0 µg/L in the main body of the Bay as the basis for initiation of a localized review of effluent limit compliance for point source discharges within the vicinity of the Bay where the trigger was exceeded.

- *Service Area*

  At least once per 5-year permit cycle, assess whether potential contributors of cyanide exist in each service area. Where potential contributors exist, implement a local program aimed at the prevention of illicit discharges to the sewer system, as have occurred in 2004 in the City of San Jose (Figure 3 of Appendix L). The local program shall consist of the following elements:

a) Identify sources of cyanide. Discuss how estimates and sources are identified in the annual PMP report. Maintain list of potential contributors (e.g., metal plating operations, hazardous waste recycling, etc.).
b) Monitor total cyanide monthly in influents and effluents using low detection level cyanide analytical methods.
c) Within a year of permit adoption, perform a site inspection of each potential contributor to assess the need to include the facility in an ongoing program.
d) For facilities in the ongoing program or those covered by the pretreatment program, follow EPA Guidance such as Industrial User Inspection and Sampling Manual for POTWs (EPA 831-B-94-01) that provides inspection and wastewater sampling procedures such as:
   i. Perform routine inspections of facilities.
   ii. Develop and distribute educational materials regarding the need to prevent illicit discharges to the sewer system.
e) Prepare an emergency monitoring and response plan to be implemented in the event that a significant cyanide discharge event occurs that causes an exceedance of effluent limits. The Plan should include procedures to verify the delivery, use and shipment of cyanide from a facility suspected of illicit discharges. (i.e. verify that State Hazardous Waste Manifests are consistent with the facility's permit application and self-monitoring report information and comparable to other disposal practices of similar local facilities).

Model Permit language to implement this action plan for cyanide control by municipal dischargers, as an NPDES permit provision, has been developed and is included as Appendix J.

10 Regulatory Analysis

This section includes the analyses required pursuant to the Administrative Procedures Act to adopt or modify a regulation. Basin Plan requirements that are unique to the San Francisco Bay Region are considered regulatory, and changes contained in the proposed BPA add regulatory provisions to the Basin Plan. To adopt these changes, the Water Board must complete an environmental checklist pursuant to the California Environmental Quality Control Act (CEQA). Since the regulatory changes are based on a change in a water quality objective, factors contained in Section 13241 of the California Water Code must be considered.

10.1 Environmental Checklist

The Porter-Cologne Water Quality Control Act and CEQA require different levels of analysis depending on the type of Basin Plan amendments. For all amendments, it is required to:

1) provide a brief description of the proposed amendment. This includes a statement of why the amendment is needed, existing background conditions, goals of the amendment, adverse environmental impacts;
2) consider reasonable alternatives to the proposed amendment;
3) describe mitigation measures to minimize any potential significant adverse environmental impacts of the proposed activity.

Sections 2, 3, 4, 7, 8 and 9 of this report satisfy the foregoing analysis requirements for the proposed BPA. Consideration of economic consequences of the implementation program will be treated below (Section 10.3) along with economic considerations for the site-specific objectives.

The proposed BPA includes changing the existing cyanide acute objectives from 1 μg/L to 9.4 μg/L and chronic objectives from 1 μg/L to 2.9 μg/L. Appendix I contains the environmental checklist for the proposed BPA. An explanation follows the environmental checklist and provides details concerning the environmental impact assessment. The analysis concludes that adopting the proposed BPA will not have any significant adverse environmental effects.

10.2 Alternatives

CEQA requires agencies to review the potential for their actions to result in adverse environmental impacts. CEQA further requires agencies to investigate alternatives and to adopt feasible measures to mitigate potentially significant impacts. To illustrate how some of the choices made in developing the proposed BPA affect its foreseeable outcomes, this analysis considers alternatives to the proposed BPA. It discusses how each alternative would affect foreseeable outcomes and the extent to which the alternative would achieve the goals of the proposed BPA.

As discussed in Appendix I, Environmental Checklist, the proposed BPA does not pose any significant adverse impacts. The alternative scenarios considered below include (1) proposed Basin Plan amendment, and (2) site-specific objective only, and (3) no Basin Plan amendment.

10.2.1 Proposed Basin Plan Amendment

The project is the proposed Basin Plan amendment presented in Appendix A. The proposed BPA is based on the technical and policy analysis described in this report. The proposed BPA includes the establishment of cyanide site-specific water quality objectives and effluent limitation policy for shallow and deep water dischargers in the San Francisco Bay region. It also includes language addressing the only other site-specific objectives in the Region, copper and nickel for Lower South San Francisco Bay. This objective was adopted by the Water Board in May 2002. The record for that action clearly indicated that effluent limitations for South Bay municipal dischargers would be mandatory, but language in the Water Quality Attainment Strategy portion of the Basin Plan did not state it clearly, only that the effluent limits would be "calculated." This change will not have economic or environmental effects, as it was the understanding of the Water Board in 2002, reflected in the transcript of the hearings as well as stakeholder meetings of the Santa Clara Basin Watershed Management Initiative, that mandatory effluent limits for Palo Alto, Sunnyvale, and San Jose/Santa Clara were the regulatory mechanism to ensure attainment of the new, less stringent site-specific objectives for copper and nickel. The calculated limits for copper and nickel are attainable by the dischargers.

As discussed above, the goals of the proposed amendment include resolving an impending compliance and enforcement issue for municipal and industrial dischargers based on a water quality objective that is no longer scientifically defensible, considering new available scientific information on *Cancer* crab species that reside in the San Francisco Bay Region. When the compliance schedules in those permits expire, the final cyanide limits based on the 1.0 μg/L cyanide objective will be violated frequently by a majority of municipal and industrial dischargers, and each violation will lead to mandatory minimum penalties (Senate Bill 709) against the discharges based on a number that is unnecessarily restrictive. If the proposed BPA is adopted, the unnecessary proliferation of enforcement actions will be averted.

The proposed BPA also includes effluent limits for shallow water dischargers that provide reasonable protection for sensitive aquatic life uses in the vicinity of each discharge.

10.2.2 No Basin Plan Amendment

Under this alternative, the Water Board would not amend the Basin Plan to adopt the proposed cyanide site-specific objectives. No new implementation activities would be initiated. The impending compliance issues for municipal and industrial discharges would not be resolved, resulting in mandatory penalties and other more stringent enforcement actions. Under this alternative, the Water Board would not amend the Basin Plan to adopt new water quality objectives. The no-action alternative would result in no change, and thus allow the enforcement actions described in Section 10.2.1 to take place. Enforcement actions would be carried through despite effluent levels that are protective of the beneficial uses of State waters (based on the receiving water studies conducted and summarized in Section 3.6). This alternative would not meet all of the proposed BPA's objectives, and would potentially lead to unnecessary and unwarranted economic and environmental impacts summarized below in Section 10.3.

10.2.3 Site-Specific Objective Only

Under this alternative, the Water Board would amend the Basin Plan to adopt the proposed marine cyanide site-specific objectives of 2.9 ug/L (chronic) and 9.4 ug/L (acute). No new implementation activities would be initiated; the default SIP procedures would be applied in determining whether an effluent limit would be required, and the limits would be calculated based on zero dilution for shallow water dischargers and 10:1 dilution for deep water dischargers. The default SIP procedures would be applied for determining whether cyanide is a pollutant of concern to be addressed in Pollutant Minimization Plans. Under this alternative, pending compliance issues for shallow water dischargers would not be resolved, resulting in mandatory penalties and other more stringent enforcement actions. Enforcement actions would be carried through despite effluent levels that are protective of the beneficial uses of State waters (based on the receiving water studies conducted and summarized in Section 3.6). This alternative would not meet all of the proposed BPA's objectives, and would potentially lead to unnecessary and unwarranted economic and environmental impacts summarized below in Section 10.3. Additional protections and surveillance, as part of the implementation plan of this proposed BPA, would not be implemented, potentially resulting in missed opportunities to minimize cyanide discharges, particularly associated with wastewater disinfection.

10.2.4 Preferred Alternative

Because the proposed BPA will not pose any significant adverse environmental impacts, any alternatives would not avoid or lessen any significant impacts. No action would result in the moderate economic impacts of unnecessary mandatory enforcement and the significant economic impacts of major capital projects to produce unnecessarily low effluent concentrations of cyanide. The analysis provided in this report, including the ambient data collected near shallow water discharge points throughout the San Francisco Bay Estuary, show that current practices protect beneficial uses with respect to (a) discharges of cyanide and (b) what the protective ambient level of cyanide should be. The proposed BPA is the preferred alternative.

10.3 Economic Considerations

CWC §13241 requires that the Water Boards consider economics when they adopt water quality objectives. At a minimum, this consideration requires a review of available information to determine whether:

- The proposed water quality objective is currently being attained; or if not,
- What methods are available to achieve compliance with the water quality objective and the costs of those methods of compliance.

10.3.1 Costs of Treatment to Meet NTR Objective for Cyanide

In March 2002, C.L. Meyer of Shell Global Solutions, Inc. prepared a technical memorandum for the Bay area cyanide working group to evaluate available treatment technologies to assess the ability to achieve a 1 μg/L effluent limit for cyanide (Meyer, 2002). The memorandum addressed the following treatment technologies:

- Alkaline Chlorination
- Ozone or Ozone/UV
- Hydrogen peroxide
- Wet Air Oxidation
- Catalytic oxidation with GAC/PAC
- Ion Exchange
- SO_2/Air Oxidation
- Polysulfide
- Biological treatment
- Precipitation
- Electrolytic decomposition
- Reverse Osmosis
- Air stripping

The analysis by Meyer included (1) a description of each technology, (2) available process data, (3) available cost information, (4) applicability to the Shell refinery, and (5) a summary comment on each process. A key finding from the analysis by Meyer is that no record exists to confirm that any of the above technologies can achieve an effluent concentration of less than 10 µg/L. Many of the alternative technologies are applicable to treatment of waste streams with influents exceeding 50 to 100 µg/L. Of the technologies examined, the most likely to be able to approach or equal an effluent cyanide concentration in the range from 1 to 5 µg/L are reverse osmosis, ozonation with UV radiation and wet air oxidation.

Unit cost estimates for these three treatment technologies are summarized below in Table 19.

Table 19: Cyanide Treatment Alternatives and Estimated Unit Costs

Treatment Alternative	Capital ($ million/mgd)	Annual ($ million/mgd)	Annualized Capital + Annual ($ million/mgd)
Ozonation plus UV	9.2	2.0	2.8
Wet air oxidation	76		6.6
Reverse Osmosis			1.34
Reverse Osmosis plus filtration			1.58

Assumptions: ENR Construction Cost Index used to adjust costs to 2005 (ENRCCI = 8290). Capital costs for Ozonation plus UV based on 1974 estimate (ENR = 2020). Capital costs for Wet Air Oxidation based on 1987 estimate (ENR = 4406). Annual costs for Reverse Osmosis and Filtration based on 1991 costs (ENR = 4835). Interest rate = 6%. 20 year planning period. Capital recovery factor = (A/P,6%, 20) = 0.08718. Refs: Meyer, 2002; NRC, 1993.

These estimates confirm that reverse osmosis would be the most economical of the three alternative technologies by a comparative percentage ranging from 73 to 465 percent.

Unit costs for the ozonation with UV radiation and wet air oxidation options were derived from cost information provided in Meyer, C.L., 2002, "Evaluation of the Treatment Technologies to achieve a 1 µg/L Effluent Limit for Cyanide". Unit costs for reverse osmosis (and prerequisite filtration) were derived from cost estimates contained in 1993 National Research Council publication titled *Managing Wastewater in Coastal Urban Areas* (NRC, 1993). The following annual unit costs (expressed as $ million per year per mgd) were derived from the information provided in the NRC publication and are used to estimate costs in this analysis:

- Filtration: $0.24 million per year per mgd
- Reverse osmosis (RO): $1.34 million per year per mgd
- Filtration plus RO: $1.58 million per year per mgd

These estimated costs are derived from annualized capital and annual operation and maintenance costs and are indexed to a 2005 construction cost index of 8290. The source document for these costs included costs with an estimated 1991 construction cost index of 4835 (Meyer, 2002).

The estimated costs of implementing reverse osmosis (i.e. constructing and operating facilities) for the dischargers that could not comply with the projected final cyanide effluent limits derived from the NTR cyanide acute and chronic objective of 1.0 ug/l is summarized in Table 20. These costs are based on application of the unit costs for either RO or filtration plus RO at the Average Dry Weather Flow capacity for each permittee, depending on the existence of filtration at a given facility.

Table 20: Cost Estimate – Reverse Osmosis Treatment as Alternative to Achieve Projected Final Cyanide Effluent Limits

NPDES Permittee	Type of Discharge	Projected Compliance Problem with Effluent Limits derived from NTR objectives?	Design Flow Rate (mgd)	Annualized Cost ($ million)(ENR 8290)
American Canyon	Shallow	Yes	2.5	3.4
Benicia, City of	Deep	Yes	4.5	7.1
Burlingame, City of	Deep	Possible		
Central Contra Costa Sanitary District	Deep	No		
Central Marin Sanitation Agency	Deep	Possible		
Delta Diablo Sanitation District	Deep	Yes	16.5	26.1
Dow Chemical Company	Deep	No (1)		
Dublin San Ramon Services District	Deep	ND		
EBDA	Deep	Yes	97.1	153.4
EBMUD	Deep	Yes	120	189.6
Fairfield-Suisun Sewer District	Shallow	Yes	17.5	23.5
GWF Nichols Rd (Site V)	Deep	ND		
Livermore, City of	Deep	ND		
Las Gallinas Valley SD	Shallow	Yes	2.9	4.6
Marin Co SD No. 5 (Tiburon)	Deep	Possible (2)		
Millbrae, City of	Deep	Possible		
Morton	Deep	ND		
Mt. View Sanitary District	Shallow	Yes	2.4	3.2
Napa SD	Deep	Possible		
Novato SD	Shallow	Yes	6.5	10.3
Palo Alto, City of	Shallow	Yes	39	52.3
Petaluma, City of	Shallow	Yes	5.2	8.2
Pinole-Hercules	Deep	Possible		
Rhodia Basic Chemicals	Deep	ND		
Rodeo Sanitary District	Deep	No (1)		
S.F.Airport, Industrial	Deep	ND		
S.F.City & County Southeast, North Point & Bayside	Deep	Possible		
San Jose Santa Clara WPCP	Shallow	Yes	167	223.8
San Mateo, City of	Deep	Possible		
Sausalito-Marin Sanitary	Deep	Yes	1.8	2.8

NPDES Permittee	Type of Discharge	Projected Compliance Problem with Effluent Limits derived from NTR objectives?	Design Flow Rate (mgd)	Annualized Cost ($ million)(ENR 8290)
District				
Sonoma County Water Agency	Shallow	Yes	3.0	4.7
South Bayside System Authority	Deep	Yes	29	45.8
South San Francisco & San Bruno	Deep	Yes	13	20.5
Sunnyvale, City of	Shallow	Yes	29.5	39.5
US Navy Treasure Island	Deep	ND		
USS - Posco	Deep	ND		
Valero Benicia Refinery	Deep	ND		
Vallejo San & Flood Control District	Deep	Yes	15.5	24.5
West County/Richmond	Deep	Possible (2)		
			573	843

As shown in the table, the total discharge that would require reverse osmosis treatment would be approximately 573 mgd. This would require an estimated annualized capital and operational costs of $843 million. In addition, an estimated 115 mgd of concentrated brine from the reverse osmosis would be generated and would require further treatment and disposal. Costs for brine treatment and disposal are not included in the above estimated costs, but need to be acknowledged as part of potential environmental impacts of no action. Reverse osmosis treatment facilities are energy intensive and would place a significant new energy demand on the San Francisco Bay Region. The adverse environmental and social impact of brine disposal and power demand associated operation of large reverse osmosis facilities would likely outweigh other environmental benefits of such facilities (SRCSD, 2003). Therefore, the use of such facilities to achieve cyanide final effluent limits derived from existing NTR water quality objectives would not represent a reasonable compliance option.

10.3.2 Costs of Conversion from Chlorination to UV Disinfection for Shallow Water Dischargers

As noted previously, a conversion from chlorination disinfection to UV disinfection provides a treatment technology alternative to reduce cyanide concentrations in effluent. However, the ability to provide reliable projections of effluent cyanide concentrations from UV disinfection is still uncertain, given the lack of full scale operating experience over a range of treatment facilities.

For evaluation purposes, as a hypothetical, it is valuable to examine the estimated costs and projected benefits of conversion to UV disinfection as a means to comply with stringent cyanide effluent limits for shallow water dischargers (i.e. limits derived without consideration for cyanide attenuation in the receiving water). The following cost analysis for the installation of UV disinfection as a replacement for chlorination facilities provides perspective on this topic.

Implementation of UV disinfection on a broad scale in the Bay area would require the following steps:

- Install either granular media filters or membrane filters ahead of UV disinfection where such facilities do not presently exist
- Remove existing chlorination equipment
- Install UV disinfection equipment, typically in new contact structures.

A breakdown showing the estimated costs for each shallow water discharger is provided in Table 21.

Table 21: Cost analysis - UV disinfection for Shallow Water Dischargers

Discharger	*Existing Design ADWF*	*Existing Filtration*	*Existing UV disinfection*	*Annual cost filtration*	*Annual cost UV*	*Total annual cost*
	(mgd)			($ million)	($ million)	($ million)
American Canyon	2.5	yes	yes	0.0	0.0	0.0
Fairfield-Suisun SD	17.5	yes	no	0.0	0.7	0.7
Las Gallinas Valley SD	2.9	no	no	0.7	0.1	0.8
Mt. View SD	2.4	yes	yes	0.0	0.0	0.0
Napa SD	15.4	yes	no	0.0	0.6	0.6
Novato SD	6.5	no	no	1.5	0.3	1.8
Palo Alto	39	yes	no	0.0	1.6	1.6
Petaluma	5.2	no	no	1.2	0.2	1.4
San Jose Santa Clara	167	yes	no	0.0	6.9	6.9
Sonoma County Water Agency	3.0	no	no	0.7	0.1	0.8
Sunnyvale	29.5	yes	no	0.0	1.2	1.2
Union SD - Hayward Marsh	20	no	no	4.7	0.8	5.5
Totals				8.8	12.7	21.5

Assumptions:
All costs in table are adjusted to ENR = 8290 (July, 2005); Annual cost recovery factor for 6%, 20 years = 0.08718. Unit costs for filtration and UV disinfection were derived from the following sources: Unit annual cost for filtration ($ million/mgd) = 0.24; Based on 1993 National Research Council publication Managing Wastewater in Coastal Urban Areas (based on ENR 4835 costs); Unit annual cost for UV disinfection ($ million/mgd) = 0.04; Based on West Yost and Associates, August 2001 report Easterly WWTP NPDES Permit Compliance Analysis (based on ENR = 6400 costs)

As indicated in Table 21, the estimated annual costs to add facilities to provide UV disinfection for all shallow water dischargers would be $21.5 million (ENR 8290).

The projected benefits of UV disinfection would include incremental reductions in the concentrations of cyanide in the effluents from 10 shallow water dischargers. The mean magnitude of these reductions would be estimated to range from 1 to 4 ug/l (see Table 16). As demonstrated by the effluent quality data for American Canyon and Mt. View Sanitary District, the use of UV disinfection will reduce but not eliminate cyanide in the effluent.

The ambient water quality benefits of such reductions in effluent concentrations are limited from a spatial perspective, since such reductions would only occur in the immediate vicinity of the shallow water discharges at the upper end of each discharge gradient. As noted elsewhere in this report, cyanide concentrations in these areas are not presently at levels that produce toxicity to sensitive aquatic organisms. Therefore, no significant benefit to aquatic life uses in these areas would be projected.

Conversion to UV disinfection would significantly reduce or eliminate chlorine usage for disinfection at the treatment facilities in question. Chlorine use for other in-plant purposes may continue. Electrical power consumption associated with operation of the UV process would be increased at these facilities. These costs are accounted for in the cost estimate summarized in Table 21.

Given the lack of demonstrable benefits to aquatic life uses and the significant costs associated with implementation of UV disinfection for all shallow water dischargers in San Francisco Bay, this approach is not warranted on the basis of cyanide concentration reduction benefits alone.

10.4 Antidegradation

Before a water quality objective can be changed, careful consideration must be given to state and federal antidegradation requirements. Guidance concerning the state and federal requirements considered in this Staff Report is set forth in the chapter of the Administrative Procedures Manual addressing Water Quality Control Plans and Policies (SWRCB, 2001). The proposed BPA is consistent with this guidance.

10.4.1 State Requirements

New water quality objectives must conform to State Board Resolution 68-16, "Statement of Policy with Respect to Maintaining High Quality of Water in California." It must be demonstrated that the change in water quality owing to relaxing the water quality objective:

- Will be consistent with maximum benefits to the people of the State;
- Will not unreasonably affect present and anticipated beneficial use of such water;
- Will not result in water quality lower than that prescribed in the applicable policies; and
- Will ensure that dischargers will implement the best practicable treatment or control.

The original cyanide marine criterion was based on the minimum amount of data for a federal criterion and it turned out to be overly conservative due to limited scientific information on crab species (Brix et al., 2000). New scientific information (Brix et al., 2000) helps justify an increase in the threshold concentration of cyanide while protecting beneficial uses of the Bay. Moreover, the cities and industries are addressing potential sources of cyanide that contribute to increases in cyanide in effluents of the treatment plants (see Sections 9.3 and 6.3). The proposed objectives are based on U.S. EPA marine cyanide criteria, which have been updated and adopted by the State of Washington. After weighing several lines of evidence, especially ambient cyanide concentrations and effects levels for the sensitive genera, impairment of beneficial uses due to current ambient concentrations of cyanide is considered unlikely. The proposed cyanide site-specific objectives were selected from ranges of possible objectives that were scientifically defensible and protective of beneficial uses in San Francisco Bay.

The proposed site-specific objectives are adequate to protect beneficial uses. A slight relaxation of the ambient water quality objectives for cyanide is unlikely to lead to increased discharges of cyanide if current performance by area dischargers is maintained as is expected. The dischargers do not have the ability to manipulate their processes to adjust effluent cyanide levels, which are influenced by many factors within the disinfection process, including wastewater characteristics, and by the occasional illicit discharge into the sanitary sewer (see Section 6.3).

Proposing new water quality objectives for cyanide is consistent with the maximum benefit to the people of the State because beneficial uses will be protected without requiring an unreasonable or unnecessary level of performance on the part of dischargers (see Section 10.3). Disinfection processes, identified as the main source of small measurable levels in effluents, are required by the Water Board to protect beneficial uses of receiving waters for recreational users, such as swimmers, kayakers, fishers and board sailers. There is not evidence that precursors to cyanide formation contained in influents can be reasonably controlled to lower the effluent levels post-disinfection.

The Cyanide Action Plan described in Section 9.3, including required effluent limitations for all municipal dischargers and those industrial dischargers that have detectable levels of cyanide and/or use cyanide in their processes, will ensure that water quality is not lowered in concert with the proposed site-specific objectives.

In general, existing federal and state policies aim to ensure that all relevant beneficial uses are protected. The proposed site-specific objectives will not result in water quality lower than that prescribed in such policies.

10.4.2 Federal Requirements

The federal regulations covering antidegradation (40 CFR 131.12) divide waters into three categories or tiers. Tier 1 waters[1] are those that are either not meeting the federal "fishable/swimmable" goals, or that meet "fishable/swimmable"[2] goals but lack assimilative capacity to accept any more of the specific pollutant proposed for discharge. Tier 2 waters are those where the water quality is better than the minimum necessary to maintain "fishable/swimmable" uses. Tier 3 waters are outstanding national resource water such as

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[1] According to EPA guidance, Questions and Answers on Antidegradation, 1985, Tier 1 waters are those where there is any existing use, whether it is fishable/swimmable or not.

[2] A level of water quality that provides for the protection and propagation of fish, shellfish and wildlife, and recreation in and on the water (USEPA, 1994)

National and State parks and wildlife refuges or waters of exceptional recreational or ecological significance.

Lowering of water quality (which could occur in the relaxation of a standard) may be done only after satisfying public participation requirements, and if the Water Board finds that (1) the relaxation of the standard is necessary to accommodate important economic or social development in the area in which the waters are located; and (2) the revised beneficial use or water quality objective is adequate to protect existing beneficial uses; and (3) the highest statutory and regulatory requirements will be imposed on all new and existing point sources and all cost-effective and reasonable best management practices will be required for nonpoint source control. Each of these three conditions will now be considered in turn.

1) *The relaxation of the standard is necessary to accommodate important economic or social development in the area in which the waters are located;*

   Unfortunately, there is relatively little guidance on how this condition should be applied. The condition may best be viewed as a balancing test. The greater the impact on water quality, the greater the justification in terms of economic or social development necessary to justify the change. The requirement that the change be justified based upon "important economic or social development in the area" is probably intended to convey the level of justification required.

   In the case of the proposed cyanide site-specific objectives, the impact on water quality is expected to be minimal. In the future, it is expected that ambient concentrations will remain similar to current levels or continue to decrease due to the actions required by the implementation plan that even drastic decreases in external loadings would have a small effect on the ambient concentrations, at least in the near term.

   The combination of the proposed site-specific objectives and implementation plan will protect water quality and accommodate current and future economic activity and population growth. These two goals can be accomplished while ensuring that little or no actual lowering of water quality will occur despite relaxing the water quality objectives for cyanide.

2) *The water quality objective is adequate to protect existing beneficial uses;*

   This consideration was addressed in Section 10.1.

3) *the highest statutory and regulatory requirements will be imposed on all new and existing point sources and all cost-effective and reasonable best management practices will be required for nonpoint source control.*

   Existing point sources (municipal and industrial discharges) will be expected to maintain their current level of performance, and any new point sources will be expected to perform up to this standard as well. In fact, the NPDES permits require the San Francisco Bay

Region POTWs to maintain their plants at peak efficiency, and this requirement certainly implies maintaining current treatment performance.

The intent of the actions described in Section 9 (implementation plan) of this report is to prevent degradation of water quality due to increases in concentrations of cyanide in SF Bay despite the relaxation of the cyanide water quality objectives. This includes required effluent limitations for all municipal dischargers and industrial dischargers that use cyanide or have detectable cyanide in their effluents, and a model permit provision for implementing the cyanide action plan of Section 9.3, included as Appendix J.

10.4.3 The Implementation Plan Protects Against Degradation

Key considerations in the assessment of consistency with anti-degradation policies include 1) analysis of the incremental change in water quality resulting from the adoption and implementation of a cyanide SSO, 2) analysis of the incremental change in cyanide mass loading resulting from the cyanide SSO, and 3) determination whether the reduction in water quality will be spatially localized or limited with respect to the water body.

The anti-degradation policies allow minor changes in both mass loadings and ambient concentrations, but do not allow significant adverse changes in ambient water quality.

Concern that water quality concentrations of cyanide in San Francisco Bay may undergo significant adverse change with the adoption and implementation of cyanide site-specific objectives that are less stringent than the current cyanide objectives in the California Toxics Rule is derived from the following hypotheses:

1. Changes in the cyanide objectives will result in less stringent effluent limits for NPDES dischargers, and
2. Effluent concentrations of cyanide from NPDES dischargers will increase as a result of less stringent effluent limits, with concentrations reaching the effluent limits, and
3. Cyanide loadings to the Bay will increase as a result of increased concentrations, and
4. Increased cyanide loadings will lead to increased concentrations of cyanide in the Bay.

An evaluation of the likelihood that adoption of site-specific cyanide objectives will result in increased concentrations of cyanide in the Bay is examined below.

Changes in Cyanide Effluent Limits

Current cyanide discharges to the Bay by point sources are controlled through existing NPDES permits. It is currently presumed that these point source discharges represent the major source of cyanide to the Bay. Review of existing NPDES permits indicates that some permits include cyanide effluent limits, while some do not (see Table 22).

Those discharges without cyanide effluent limits shown in Table 22 do not have reasonable potential to cause or contribute to the violation of the current NTR objectives. No change in cyanide effluent limits would be expected for those dischargers.

The dischargers with interim cyanide effluent limits are listed in Table 22. This table lists the existing interim limits in NPDES permits and the projected final effluent cyanide limits that will be adopted if the proposed cyanide SSOs are adopted. Comparison of existing interim limits with projected final limits indicates that the following discharges would have less stringent final limits than their current interim limits after adoption of the proposed cyanide SSOs:

- American Canyon
- City of Burlingame
- Central Contra Costa Sanitary District
- Delta Diablo Sanitation District
- East Bay Dischargers Authority
- East Bay Municipal Utilities District
- Fairfield-Suisun Sewer District
- Las Gallinas Valley Sanitary District
- Marin County Sanitary District No. 5
- City of Millbrae
- Mt. View Sanitary District
- Napa Sanitary District
- Novato Sanitary District
- City of Palo Alto
- City of Petaluma
- Cities of Pinole and Hercules
- Rodeo Sanitary District
- San Francisco International Airport
- City of San Mateo
- Sausalito-Marin City Sanitary District
- Sonoma County Water Agency
- South Bayside System Authority
- South San Francisco/San Bruno
- City of Sunnyvale
- Vallejo Sanitation and Flood Control District
- West County Agency
- Martinez Refining Company

The above dischargers are all either deep water dischargers that receive a minimum of 10:1 dilution through high rate diffusers or shallow water dischargers that will receive new final effluent limits under the proposed BPA. These dischargers would potentially receive increased discharge limits as the sole result of adoption of the proposed cyanide SSOs or the proposed shallow water discharger effluent limits.

Table 22: Cyanide Effluent Limits- Existing and Projected Final Based on Proposed SSOs

												Projected Final Effluent Limits	
Discharger	Discharger Type	NPDES Permit #	Order #	Permit Expiration Date	Daily Max (ug/L)	Daily Average (ug/L)	Monthly Avg (ug/L)	Interim Daily Avg (ug/L)	Interim Daily Max (ug/L)	Interim Monthly Average (ug/L)		AMEL (ug/l)	MDEL (ug/l)
American Canyon, City of	POTW	CA0038768	00-003	1/19/2005		5.0						10.4	19.1
Angel Island State Park	POTW	CA0037401	93-022	3/17/1998		25.0							
Benicia, City of	POTW	CA0038091	01-096	7/31/2006						25		18.3	44.1
Burlingame, City of	POTW	CA0037788	R2-2002-0027	1/31/2007					10			20.1	40.2
Calistoga, City of	POTW	CA0037966	00-131	11/29/2005					8.2				
Central Contra Costa Sanitary District	POTW	CA0037648	01-068	5/31/2006					18			21.4	35.9
Central Marin Sanitation Agency	POTW	CA0038628	01-105	8/31/2006					25			19.4	41.9
Central Contra Costa Sanitation District #5, Port Costa	POTW	CA0037885	R2-2003-0009	12/31/2007					-		No Limit		
Delta Diablo Sanitation District	POTW	CA0038547	R2-2003-0114, R2-2004-027	1/1/2009					25			20.1	40.2
Dublin San Ramon Services District	POTW	CA 0037613	00-088	8/16/2005					21			ND	ND
East Bay Dischargers Authority	POTW	CA 0037869	00-087	8/16/2005					21			15.2	44.5
East Bay Municipal Utilities District	POTW	CA0037702	01-072, R2-2003-0088	5/31/2006 / 6/30/2006					10			18.8	43.2
Fairfiend-Suisun Sewer District	POTW	CA0038024	R2-2003-0072	9/30/2008					32			8.4	21.3
Hayward Marsh	POTW	CA0038636	99-024	5/25/2004				17.1				9.0	20.5

Discharger	Discharger Type	NPDES Permit #	Order #	Permit Expiration Date	Daily Max (ug/L)	Daily Average (ug/L)	Monthly Avg (ug/L)	Interim Daily Avg (ug/L)	Interim Daily Max (ug/L)	Interim Monthly Average (ug/L)		Projected Final Effluent Limits AMEL (ug/l)	Projected Final Effluent Limits MDEL (ug/l)
Las Gallinas Valley Sanitary District	POTW	CA0037851	R2 2003-0108	11/30/2008					19			9.0	20.4
Livermore, City of	POTW	CA 0038008	00-089	8/16/2005					21				
Marin County Sanitary District #5	POTW	CA0037753	R2-2002-0097	10/31/2007				25				20.1	40.2
Millbrae, City of	POTW	CA0037532	01-143	10/31/2006						10		19.4	41.9
Mt. View Sanitary District	POTW	CA0037770	00-086	8/16/2005							No Limit	9.5	19.1
Napa Sanitation District	POTW	CA0037575	00-059, R2-2002-0111	7/31/2005					25			8.4	22.8
Novato Sanitaty District	POTW	CA0037958	99-036, R2-2003-0029	5/25/2004		5.0						9.3	19.7
Palo Alto, City of	POTW	CA0037834	R2-2003-0078	9/30/2008					32			10.8	16.3
Petaluma, City of	POTW	CA0037810	98-076	7/15/2003				14				8.8	20.9
Pinole-Hercules, Cities of	POTW	CA0037796	01-106	8/1/2006					12			20.7	38.2
Rodeo Sanitary District	POTW	CA0037826	01-107	8/31/2006					12			22.1	33.2
St. Helena, City of	POTW	CA0038016	92-006	1/15/1997		52							
San Francisco International Airport	POTW	CA0038318	01-145	10/31/2006					10			20.1	40.2
San Francisco, City and County of, Southeast (Total)	POTW	CA0037664	R2-2002-0073	5/31/2007							No RP	20.7	38.2
San Jose/Santa Clara WPCP	POTW	CA003784	R2 2003-0085	9/30/2008							No RP	10.4	17.8
San Mateo, City of	POTW	CA0037541	01-071	5/31/2006					10			20.7	38.2

												Projected Final Effluent Limits	
Discharger	**Discharger Type**	**NPDES Permit #**	**Order #**	**Permit Expiration Date**	**Daily Max (ug/L)**	**Daily Average (ug/L)**	**Monthly Avg (ug/L)**	**Interim Daily Avg (ug/L)**	**Interim Daily Max (ug/L)**	**Interim Monthly Average (ug/L)**		**AMEL (ug/l)**	**MDEL (ug/l)**
Sausalito-Marin City Sanitary District	POTW	CA0038067	00-060	7/19/2005					25			20.7	38.2
Seafirth Estates	POTW	CA0038393	96-152	11/20/2001							No Limits		
Sewerage Agency of Southern Marin	POTW	CA0037711	01-070	5/30/2006					25				
Sonoma Valley County Sanitary District	POTW	CA0037800	R2-2002-0046	2/28/2007						10.1		8.8	20.8
South Bayside System Authority	POTW	CA0038369	01-012	2/1/2006					18			21.4	35.9
South San Francisco/San Bruno WQCP	POTW	CA0038130	R2 2003-0010	3/31/2008					10			12.7	40.3
Sunnyvale, City of	POTW	CA0037621	R2 2003-0079	9/30/2008					32			8.8	21.8
Treasure Island WWTP	POTW	CA0110116	R2-2004-XXXX	Tentative					10				
Union Sanitary District, Wet Weather	POTW	CA0038733	R2-2004-0002	2/28/2009					10				
Vallejo Sanitation & Flood Control District (Total)	POTW	CA0037699	00-026	4/19/2005					10			17.8	44.8
West County Agency	POTW	CA0038539	01-144	10/31/2006					25			20.1	40.2
Yountville, Town of	POTW	CA0038121	R2-2004-XXXX	Tentative	88		39						
Chevron Richmond Refinery	Refinery	CA0005134	01-067	5/31/2006	25							20.7	38.2
ConocoPhillips (Rodeo)	Refinery	CA0005053	00-015	3/15/2005	25							21.4	35.9

												Projected Final Effluent Limits	
Discharger	**Discharger Type**	**NPDES Permit #**	**Order #**	**Permit Expiration Date**	**Daily Max (ug/L)**	**Daily Average (ug/L)**	**Monthly Avg (ug/L)**	**Interim Daily Avg (ug/L)**	**Interim Daily Max (ug/L)**	**Interim Monthly Average (ug/L)**		**AMEL (ug/l)**	**MDEL (ug/l)**
Martinez Refining Company	Refinery	CA0005789	01-141	10/31/2006					25			21.4	35.9
Tosco Corporation (Avon)	Refinery	CA0004961	00-011	2/16/2005	25								
Valero Benicia Refinery	Refinery	CA0005550	2002-0112	11/30/2007					25				
C&H Sugar	Industrial	CA0005240	00-025	4/19/2005							No Limits		
Crockett Cogeneration	Industrial	CA0029904	98-100	9/16/2003							No Limits		
Dow Chemical Company	Industrial	CA0004910	01-142	10/31/2006							No Limits	20.1	40.2
General Chemical	Industrial	CA000497	R2-2002-0071	5/31/2007							No Limits		
GWF Power Systems (Site I)	Industrial	CA0029106	99-056	7/21/2004							No Limits	20.1	40.2
GWF Power Systems (Site V)	Industrial	CA0029122	99-057	7/21/2004							No Limits		
Hanson Aggregates (Amador Street)	Industrial	CA0030139	98-062	7/15/2003							No Limits		
Hanson Aggregates (Olin Jones Dredge Spoils Disposal)	Industrial	CA0028321	01-112	10/16/2006							No Limits		
Hanson Aggregates (Tidewater Avenue)	Industrial	CA0030147	98-118	7/15/2003							No Limits		
Morton	Industrial	CA0005185	97-025	2/19/2002							No Limits		
Pacific Gas & Electric (East Shell Pond)	Industrial	CA0030082	99-022	5/25/2004							No Limits		
Pacific Gas & Electric (Hunters Point)	Industrial	CA0005649	94-057	5/18/1999							No Limits		

												Projected Final Effluent Limits	
Discharger	**Discharger Type**	**NPDES Permit #**	**Order #**	**Permit Expiration Date**	**Daily Max (ug/L)**	**Daily Average (ug/L)**	**Monthly Avg (ug/L)**	**Interim Daily Avg (ug/L)**	**Interim Daily Max (ug/L)**	**Interim Monthly Average (ug/L)**		**AMEL (ug/l)**	**MDEL (ug/l)**
Rhodia Basic Chemicals	Industrial	CA0006165	98-104	10/21/2003							No Limits		
S.F.Airport, Industrial (Total)	Industrial	CA0028070	R2 2002-0045	2/28/2007							No RP		
Southern Energy California Pittsburg Power Plant	Industrial	CA0004880	R2-2002-0072	5/31/2007							No Limits		
Southern Energy Delta LLC Potrero Power Plant	Industrial	CA0005657	94-056	5/18/1999							No Limits		
US Navy Point Molate	Industrial	CA0030074	97-045	3/19/2002		25							
USS Posco	Industrial	CA0005002	00-130	11/29/2005							No Limits		

Changes in Effluent Cyanide Concentrations

The hypothesis that effluent cyanide concentrations will increase if less stringent cyanide effluent limits are established in the above listed NPDES permits is not supported by the analysis of treatment plant operations or processes.

Available data indicates that, for treatment plants in the Bay area, effluent cyanide concentrations are not a function of influent concentrations. As noted in Section 3.5, for many plants, influent cyanide concentrations are lower than effluent cyanide concentrations. For the remaining plants, no relationship exists between influent and effluent concentrations. Therefore, an argument that less stringent effluent limits would tend to encourage increased influent cyanide loadings that would result in higher effluent concentrations of cyanide is not tenable. Cyanide concentrations in effluent are not well explained, but are believed to be the complicated result of chlorination, dechlorination or UV disinfection. Operation of the physical and biological treatment processes used in Bay area treatment plants to achieve secondary treatment is required to meet technology-based federal requirements and will not be modified by plant operators to achieve less stringent cyanide effluent limits. Further, no reliable information exists to suggest that changes in such operations will affect cyanide effluent concentrations. In other words, municipalities and industries have neither an incentive nor capability to "re-operate" their plants to "take advantage" of less stringent cyanide limits. For this reason, changes in cyanide concentrations resulting from changes in cyanide effluent limits are not likely. The more plausible expectation is that cyanide levels in effluent will remain at current levels, despite changes in effluent limits.

The potential for contributors to municipal facilities to take advantage of higher effluent limits through increased discharges to sanitary sewers is offset by 1) local limits derived from mandatory effluent limits and 2) a periodic review by every municipal discharger, in a permit provision, every 5 years (permit reissuance) of potential cyanide dischargers to the sanitary sewer and report to the Water Board. This higher level of cyanide surveillance will counter any potential efforts to increase discharges to sanitary sewers.

Changes in Cyanide Loadings

In the unlikely event that effluent concentrations increase in response to less stringent effluent limits (in opposition to the above analysis), cyanide loadings to the Bay would increase. Table 23 provides a summary of the maximum incremental changes in cyanide loadings to the Bay resulting from discharges at the projected final effluent limit concentrations. The maximum potential incremental increase in cyanide loadings over current loadings is 20 kilograms per day. The magnitude of these incremental changes can be viewed in relation to (a) current mass of cyanide in the Bay and (b) allowable loadings of cyanide to the Bay, i.e. the assimilative capacity of the Bay for cyanide. The current mass of cyanide in the water column of the Bay is less than or equal to 2,700 kg. This is calculated based on an average cyanide concentration of less than 0.4 µg/L and modeled estimates of the estuary's mean volume of 6.66 billion cubic meters. Assimilative capacity of the Bay under the current CTR objectives and the proposed cyanide SSOs are calculated as follows:

> ***Assimilative capacity under CTR = Current cyanide objectives per CTR X estimated water volume of the Bay X Multiplier to convert to kg = 6,700 kg***

Assimilative capacity under proposed SSOs = Proposed SSO X estimated volume of the Bay X Multiplier to convert to kg = 19,300 kg

The total potential increase in cyanide loadings (presuming that all dischargers will increase from existing loadings to loadings allowed by new effluent limits) (20 kilograms per day) is approximately 0.7 percent of the current cyanide mass in the Bay water column, 0.3 percent of the cyanide mass allowed in the Bay under the NTR cyanide standard of 1.0 μg/L, and 0.1 percent of the cyanide mass allowed in the Bay under the proposed cyanide SSO of 2.9 μg/L (4-day average). Remembering that cyanide discharged to the Bay attenuates quickly, these minor incremental loading estimates would not be expected to have a measurable impact on ambient cyanide levels in the Bay.

Table 23: Hypothetical Cyanide Loadings at Projected Final Effluent Limits

NPDES Permittee	Average annual flow (mgd)	Projected Final Effluent Limit (AMEL) (ug/l)	Existing Mean Effluent Concentration (ug/l)	Loading at Projected AMEL (kg/day)	Existing Mean Loading (kg/day)	Hypothetical Increased Loading (kg/day)
American Canyon	1.3	10.4	1.4	0.06	0.01	0.06
City of Burlingame	4.1	20.1	3.3	0.31	0.05	0.26
Central Contra Costa SD	43.1	21.4	3.8	3.50	0.61	2.88
Central Marin Sanitation Agency	7.4	19.4	4.3	0.54	0.12	0.42
Delta Diablo Sanitation District	13.1	20.1	7.1	1.00	0.35	0.65
East Bay Dischargers Authority	77.9	15.2	5.1	4.49	1.51	2.97
East Bay MUD	71.5	18.8	5.7	5.10	1.56	3.54
Fairfield Suisun SD	16.6	8.4 [c]	3.9	0.53	0.25	0.39
Hayward Marsh (effluent)[d]		9.0 [c]	2.9			
Las Gallinas Valley SD	1.3	9.0 [c]	3.0	0.04	0.01	0.03
Marin County SD No. 5	0.6	20.1	5.0	0.05	0.01	0.03
Martinez Refining Company	6.7	21.4	13.2	0.54	0.34	0.21
City of Millbrae	2.4	19.4	3.7	0.18	0.03	0.14
Mt. View SD	2.0	9.5 [c]	0.5	0.07	0.00	0.07
Napa SD	7.9	8.4 [c]	2.6	0.25	0.08	0.17
Novato SD	5.2	9.3 [c]	1.8	0.18	0.03	0.15
City of Palo Alto	26.8	10.8 [c]	3.3	1.10	0.33	0.77
City of Petaluma	3.3	8.8 [c]	2.9	0.11	0.04	0.07
Cities of Pinole and Hercules	2.4	20.7	3.5	0.19	0.03	0.16
Rodeo SD	0.9	22.1	3.7	0.08	0.01	0.06
San Francisco International Airport	0.6	20.1	9.8	0.05	0.02	0.02
San Jose Santa Clara WPCP	115.1	10.4 [c]	2.8	4.53	1.24	3.30
City of San Mateo	10	20.7	4.3	0.78	0.16	0.62
Sausalito-Marin City	1.7	20.7	9.6	0.13	0.06	0.07
Sonoma County Water Agency	2.3	8.8 [c]	3.2	0.08	0.03	0.05
South Bayside System Authority	15.5	21.4	7.8	1.26	0.46	0.80
South San Francisco/San Bruno	10.4	12.7	8.0[b]	0.50	0.32	0.19
City of Sunnyvale	14.4	8.8 [c]	4.4	0.48	0.24	0.24
Vallejo Sanitation and Flood Control District	11.4	17.8	4.8	0.77	0.21	0.56
West County Agency	13.1	20.1	3.6	1.00	0.18	0.82
Totals	**488**			**27.90**	**8.29**	**19.70**

[a] Table shows loadings for discharges where projected final effluent limits exceed existing interim limits.

[b] Median value used.

[c] AMEL based on Attenuation Factor of 3.5.

[d] Average annual flow data not available at date of draft report release.

Changes in Ambient Cyanide Concentrations

In the unlikely event cyanide concentrations increase as a result of adoption of the proposed cyanide SSOs, ambient concentrations would change marginally in the vicinity of the affected shallow water discharges. Current ambient concentrations of cyanide at deep water sites in the Bay are typically less than 0.4 µg/L, while concentrations near shallow water discharges are usually less than 2.9 µg/L, sometimes as high as 4 or 6 µg/L. These ambient concentrations reflect the current source loading of cyanide to the Bay at existing effluent concentrations. Given the minor magnitude of the resulting potential increase in mass loadings as described above, significant changes in ambient cyanide concentrations would not be anticipated.

Overall Assessment

Based on the above analysis, adoption and implementation of the proposed cyanide SSO is not predicted to result in significant increased loadings or increased concentrations of cyanide in the Bay. As such, the proposed adoption of site-specific objectives for cyanide would be consistent with State and federal anti-degradation policies.

11 Conclusions

The proposed site-specific objectives (SSOs) and implementation plan are needed and warranted as a Basin Plan amendment for numerous reasons. Water Board staff, in its best professional judgment, recommends the Water Board amend the Basin Plan to adopt the SSO and implementation plan for required effluent limitations and cyanide pollution prevention, to ensure ongoing protection of beneficial uses and water quality, and to set reasonable, attainable limits for the communities and industries of the San Francisco Bay Region. Specific reasons for adopting the proposed Basin Plan Amendment are summarized below.

Cyanide is a non-conservative pollutant

Cyanide is a non-conservative pollutant and does not persist in an aquatic environment. It is appropriate to acknowledge not only dilution, but also the degradation of cyanide in aquatic environments when formulating effluent limitations for shallow water dischargers. The attenuation (dilution plus degradation) of cyanide in shallow water environments has been documented thoroughly in Appendices D and L, and is recommended as a basis for derivation of required cyanide effluent limits for all shallow water dischargers.

Proposed site-specific objective is conservative

Given the current state of analytical cyanide detection capabilities, the proposed site-specific water quality objectives have an intrinsic margin of safety. The existing analytical methods for measuring cyanide in wastewater cannot effectively discern free cyanides from the less toxic complexed cyanides. Although the total or weak acid-dissociable cyanide in wastewater from POTWs is partially free cyanides, all detected cyanide (total cyanide) is assumed to be free cyanide. The NTR criteria, as well as the proposed SSOs, were formulated using controlled laboratory concentrations of free cyanide. Therefore the proposed SSOs are inherently conservative since they do not account for the less-toxic metal-cyanide complexes. Consequently, any given measurement of cyanide in ambient waters or POTW effluent will over-represent the actual concentration of the harmful cyanide constituent.

Proposed site-specific objective is formulated from an improved data set

The proposed site-specific objective reflects an improvement of the original dataset used to derive water quality criteria and effluent limits. The existing national criteria were calculated in 1985 using only the minimum data set required per U.S. EPA guidelines. Also, *Cancer* specimens native to the east coast of the United States were used in the data set. The east coast specimens yielded sensitivity values six times that of the next-sensitive *Cancer* species. The improved data set for the proposed amendment displaces the east-coast species with four species of *Cancer* native to the San Francisco Bay region. Utilizing a more robust data set with native species yields a new site-specific objective that has more scientific and regional validity. The State of Washington used this improved data set to propose the similar SSOs for Puget Sound in 1997.

Cyanide in effluent is a by-product of wastewater disinfection

Cyanide formation in wastewater effluent is a by-product of the disinfection process. The disinfection process is a mandatory procedure that dischargers must implement to protect the water recreation and other beneficial uses of the Bay. There is not currently a procedure available that could practicably be instituted to entirely remove or eliminate the cyanide by-product (see Section 10.3). Ambient cyanide concentrations throughout the Bay demonstrate that the beneficial uses of the Bay are currently protected from cyanide impacts given the status quo of POTW facility operations. If these disinfection processes were eliminated to achieve the current national criteria objective for cyanide, then the water recreation beneficial uses of the Bay would no longer be protected.

Proposed shallow water discharger policy will prevent unnecessary enforcement actions

The Bay area dischargers are not meeting the current national criteria for cyanide. Mandatory minimum penalties are not being exercised by the State because of interim effluent limits that were written into discharger permits to allow time for compliance. In years 2005 and 2006, these interim limits will expire and mandatory minimum penalties will be in effect. As noted previously, it is the professional judgment of the Water Board that the proposed BPA will be protective of Bay area waters. Expiration of the interim effluent limits without adoption of the proposed BPA will result in the Water Board staff assigning staff resources to mandatory enforcement actions that will yield little or no environmental benefit.

Additionally, a compliance problem will result for many shallow water dischargers if the proposed site-specific cyanide objectives are implemented without consideration for cyanide attenuation. The proposed implementation plan will establish effluent limits that account for cyanide attenuation and also provide reasonable protection of sensitive aquatic life uses in the vicinity of shallow water discharges and meet all other provisions of the Basin Plan and SIP for the establishment of dilution credit and mixing zones (see Appendix K).

Antidegradation is ensured through individual effluent limits and the model permit provision for a Regional Cyanide Action Plan (Appendix J)

All individual shallow and deep water municipal dischargers to the Bay will be subject to numeric cyanide effluent limits in their NPDES permit to enforce compliance with the proposed site-specific water quality objectives. All industrial dischargers that disinfect, use cyanide or have detectable cyanide in their effluents will have effluent limits as well. The establishment of required effluent limits is a part of the plan to assure discharger accountability and compliance with State and federal antidegradation requirements.

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Appendix A

Proposed Basin Plan Amendment

Insert the following language in Table 3-3 of Chapter 3 of the Basin Plan:

TABLE 3-3 MARINE [a] WATER QUALITY OBJECTIVES FOR TOXIC POLLUTANTS FOR SURFACE WATERS (ALL VALUES IN UG/L)

COMPOUND	4-DAY AVERAGE	1-HR AVERAGE	24-HR AVERAGE
Arsenic [b, c, d]	36	69	
Cadmium [b, c, d]	9.3	42	
Chromium VI [b, c, d, e]	50	1100	
Copper [c, d, f]			
Cyanide [g]	2.9	9.4	
Lead [b, c, d]	8.1	220	
Mercury [h]	0.025	2.1	
Nickel [b, c, d]	8.2	74	
Selenium [i]			
Silver [b, c, d]		1.9	
Tributyltin [j]			
Zinc [b, c, d]	81	90	
PAHs [k]			15

NOTES:

a. Marine waters are those in which the salinity is equal to or greater than 10 parts per thousand 95% of the time, as set forth in Chapter 4 of the Basin Plan. Unless a site-specific objective has been adopted, these objectives shall apply to all marine waters except for the South Bay south of Dumbarton Bridge, where the California Toxics Rule (CTR) applies. For waters in which the salinity is between 1 and 10 parts per thousand, the applicable objectives are the more stringent of the freshwater (Table 3-4) or marine objectives.

b. Source: 40 CFR Part 131.38 (California Toxics Rule or CTR), May 18, 2000.

c. These objectives for metals are expressed in terms of the dissolved fraction of the metal in the water column.

d. According to the CTR, these objectives are expressed as a function of the water-effect ratio (WER), which is a measure of the toxicity of a pollutant in site water divided by the same measure of the toxicity of the same pollutant in laboratory dilution water. The 1-hr. and 4-day objectives = table value X WER. The table values assume a WER equal to one.

e. This objective may be met as total chromium.

f. Water quality objectives for copper were promulgated by the CTR and may be updated by U.S. EPA without amending the Basin Plan. Note: at the time of writing, the values are 3.1 ug/l (4-day average) and 4.8 ug/l (1-hr. average). The most recent version of the CTR should be consulted before applying these values.

g. Site-specific objectives for cyanide, based on recalculation of the national water quality criteria to include available toxicity data for crabs of the genus *Cancer*. ~~Cyanide criteria were promulgated in the National Toxics Rule (NTR). The NTR criteria specifically apply to San Francisco Bay upstream to and including Suisun Bay and Sacramento-San Joaquin Delta. Note: at the time of writing, the values are 1.0 ug/l (4-day average) and 1.0 ug/l (1-hr. average).~~

h. Source: U.S. EPA Ambient Water Quality Criteria for Mercury (1984). The CTR human health criteria for mercury are also legally applicable to all waters of the San Francisco Bay Region.
i. Selenium criteria were promulgated for all San Francisco Bay/Delta waters in the National Toxics Rule (NTR). The NTR criteria specifically apply to San Francisco Bay upstream to and including Suisun Bay and Sacramento-San Joaquin Delta. Note: at the time of writing, the values are 5.0 ug/l (4-day average) and 20 ug/l (1-hr. average).
j. Tributyltin is a compound used as an antifouling ingredient in marine paints and toxic to aquatic life in low concentrations. U.S. EPA has published draft criteria for protection of aquatic life (Federal Register: December 27, 2002, Vol. 67, No. 249, Page 79090-79091). These criteria are cited for advisory purposes. The draft criteria may be revised.
k. The 24-hour average aquatic life protection objective for total PAHs is retained from the 1995 Basin Plan. Source: U.S. EPA 1980.

Insert the following language in the Section of Chapter 4 of the Basin Plan from page 4-7 of the 1995 printed version of the Basin Plan:

EFFLUENT LIMITATIONS

TECHNOLOGY- AND WATER QUALITY-BASED LIMITATIONS

The federal Clean Water Act (CWA) requires that NPDES permits include technology-based and, where appropriate, water quality-based effluent limitations. Technology-based effluent limitations are promulgated performance standards based on secondary treatment or best practicable control technology. When technology-based limitations fail to attain or maintain acceptable water quality (as measured by water quality objectives) or comply with water quality control plans, additional or more stringent effluent limitations will be required in order to attain water quality objectives. The more stringent limitations are known as water quality-based limits.

Water quality-based effluent limitations will consist of narrative requirements and, where appropriate, numerical limits for the protection of the most sensitive beneficial uses of the receiving water. Establishing numeric limits takes into account the appropriate water quality objectives, background concentrations in the receiving water, and allowable dilution credit.

In many cases, numerical water quality objectives are not available for various types of beneficial uses or for various constituents of concern.   In these cases, best professional judgment will be used in deriving numerical effluent limitations that will ensure attainment and maintenance of narrative water quality objectives.

SITE-SPECIFIC OBJECTIVES

In some cases, the Water Board may elect to develop and adopt site-specific water quality objectives. These objectives will be based on reflect site-specific conditions and comply with the Antidegradation Policy. This situation may arise when:

· It is determined that promulgated water quality standards or objectives are not protective of beneficial uses; or

· Site-specific conditions warrant less stringent effluent limits than those based on promulgated water quality standards or objectives, without compromising the beneficial uses of the receiving water.

In the above cases, the Regional Board may consider developing and adopting site-specific water quality objectives for the constituent(s) of concern. These site-specific objectives will be developed to provide the same level of environmental protection as intended by national criteria, but will more accurately reflect local conditions. Such objectives are subject to approval by the State Board, Office of Administrative Law, and U.S. EPA.

There may be cases where the promulgated water quality standard or adopted objectives are practically not attainable in the receiving water due to existing high concentrations. In such circumstances, discharges shall not cause impairment of beneficial uses.

Site-specific objectives have been adopted by the Water Board for copper and nickel in San Francisco Bay south of the Dumbarton Bridge (Lower South Bay, Table 3-3A) and cyanide for marine waters (Table 3-3).

Insert the following language in the Section of Chapter 4 of the Basin Plan from page 4-13 of the 1995 printed version of the Basin Plan:

IMPLEMENTATION OF EFFLUENT LIMITATIONS

In incorporating and implementing effluent limitations in NPDES permits, the following general guidance shall apply:

(A) PERFORMANCE-BASED LIMITS

Where water quality objectives in the receiving water are being met, and an existing effluent limitation for a substance in a discharge is significantly lower than appropriate water quality-based limits, performance-based effluent limitations for that substance may be specified or the effluent limit revised. Any changes are subject to compliance with the state Antidegradation Policy. The performance-based effluent limitation may be either concentration- or mass-based, as appropriate.

(B) SITE-SPECIFIC OBJECTIVE INCORPORATION

Once the Water Board has adopted a site-specific objective for any substance, effluent limitations shall be calculated from that objective in accordance with the ~~the methods described above.~~methodology in the SIP and any amendments thereto. On a pollutant-by-pollutant basis, the Water Board may require effluent limitations to implement the site-specific objectives, for instance to ensure compliance with state and federal antidegradation policies.

Site-specific objectives for copper and nickel in Lower South San Francisco Bay (Table 3-3A) and cyanide in marine waters (Table 3-3) are incorporated into required effluent limitations for specific dischargers.

COPPER AND NICKEL IN LOWER SOUTH SAN FRANCISCO BAY

As part of the implementation plan for copper and nickel site-specific objectives, the municipal dischargers south of Dumbarton Bridge shall have effluent limitations for copper and nickel, derived from the site-specific objectives in Table 3-3A using SIP methodology. The Water Quality Attainment Strategy for copper and nickel in Lower South Bay that implements these site-specific objectives is included in Chapter 7.

CYANIDE

Cyanide in effluents is formed as a by-product of disinfection, and is present in low levels in all municipal effluents and most industrial effluents. As part of the implementation plan for cyanide marine site-specific objectives, all municipal dischargers in the San Francisco Bay Region for whom the site-specific objectives are applicable shall have effluent limitations for cyanide, derived from the site-specific objectives in Table 3-3 using SIP methodology. Cyanide effluent limitations for shallow water dischargers are calculated by substituting an attenuation factor (AF) of 3.5 for the dilution credit, D, in the SIP (ECA) equation. Cyanide effluent limitations for deep water dischargers are calculated according to SIP methodology. Industrial dischargers in the San Francisco Bay Region for whom the site-specific objectives are applicable shall have effluent limitations for cyanide, calculated according to SIP methodology, except where the discharger demonstrates that it does not detect cyanide in the effluent using a method detection limit of 1.0 ug/l, does not disinfect all or a portion of the effluent, or otherwise demonstrates that cyanide is not used in the industrial process.

The AF of 3.5 is specifically established for cyanide, a non-conservative pollutant, and it accounts for its degradation in receiving waters of shallow water discharges as well as its dilution. As part of the region-wide Cyanide Action Plan to maintain or improve current performance, all dischargers for whom the site-specific objectives are applicable shall have permit provisions to review sources of cyanide to their effluent at least once per five years, to ensure that water quality objectives are met and beneficial uses protected. If ambient monitoring conducted by the Regional Monitoring Program indicates cyanide concentrations in the main body of the San Francisco Bay Estuary of 1.0 ug/L or higher, a localized review shall be initiated of effluent limit compliance for point source discharges within the vicinity of the Bay where the trigger was exceeded, and these affected dischargers shall participate in the review to determine and abate any identified sources.

(C) AVERAGING PERIODS

For some substances there may be more than one effluent limitation with different averaging periods (e.g., daily average and 30-day average). In both cases, the effluent limitations shall apply to the mean concentration of all samples analyzed during the averaging period. If only one sample is taken during the averaging period, the effluent limitation applies to the concentration of that sample.

(D) METHOD DETECTION LIMITS, PRACTICAL QUANTITATION LEVELS (PQL), AND LIMITS OF QUANTIFICATION (LOQ)

Method Detection Limits are defined in Title 40, Code of Federal Regulations, Part 136, Appendix B (revised June 30, 1986).

Practical Quantitation Level is the lowest concentration of a substance within plus or minus 20 percent of the true concentration by 75 percent of the analytical laboratories testing in a performance evaluation study. If performance data are not available, the PQL is the MDL x 5 for carcinogens and the MDL x 10 for noncarcinogens.

Limits of Quantification are ten standard deviations greater than the average measured blank values used in developing the MDL.

These terms and concepts are useful when pollutant concentrations in waters are relatively low. However, these will be taken into account in determining compliance with, rather than in the calculation of, effluent limitations.

(E) SELECTION OF PARAMETERS

Effluent limits are not necessary for substances that do not pose any risk to beneficial uses or are shown not to be present in discharge. However, a discharger must demonstrate to the satisfaction of the Regional Board that particular substances do not cause, or have the reasonable potential to cause or contribute to an excursion above numerical and narrative objectives under procedures outlined in the SIP and any amendments thereto. ~~Dischargers must also demonstrate that pollutants of concern are (a) not in the waste stream, and (b) no change has occurred that may cause release of pollutants. This certification shall be supported, at a minimum, by monitoring results for such pollutants and process and treatment descriptions that demonstrate these substances are not expected to be present in the waste stream. At a minimum, this monitoring and certification is required prior to issuance and reissuance of WDRs.~~

The Regional Board may choose to not require periodic monitoring for pollutants in low volume discharges determined to have no significant adverse impact on water quality.

(F) COMPLIANCE SCHEDULES

As new objectives or standards are adopted, permits will be revised accordingly. Revised permits will distinguish between effluent limitations that are met by current performance, and effluent limitations not currently attained. Immediate compliance will be required for effluent limitations that are met by current performance.

The Regional Board may consider dischargers' proposals for longer compliance schedules for newly adopted objectives or standards as NPDES permit conditions for particular substances, where revised effluent limitations are not currently being met and where justified. The primary goal in setting compliance schedules is to promote the completion of source control and waste minimization measures, including water reclamation.

Justification for compliance schedules will include, at a minimum, all of the following:

(a) Submission of results of a diligent effort to quantify pollutant levels in the discharge and the sources of the pollutant in the waste stream;

(b) Documentation of source control efforts currently underway or completed, including compliance with the Pollution Prevention program described in the Basin Plan;

(c) A proposed schedule for additional source control measures or waste treatment; and

(d) A demonstration that the proposed schedule is as short as possible.

Implementation of source control measures to reduce pollutant loadings to the maximum extent practicable shall be completed as soon as possible, but in no event later than four years after new objectives or standards take effect. Implementation of any additional measures that may be required to comply with effluent limitations shall be completed as soon as possible, but in no event later than ten years after new objectives or standards take effect. The issuance of the permit containing a compliance schedule should not result in a violation of any applicable requirement of the federal Clean Water Act or the California Water Code, including any applicable Clean Water Act statutory deadlines.

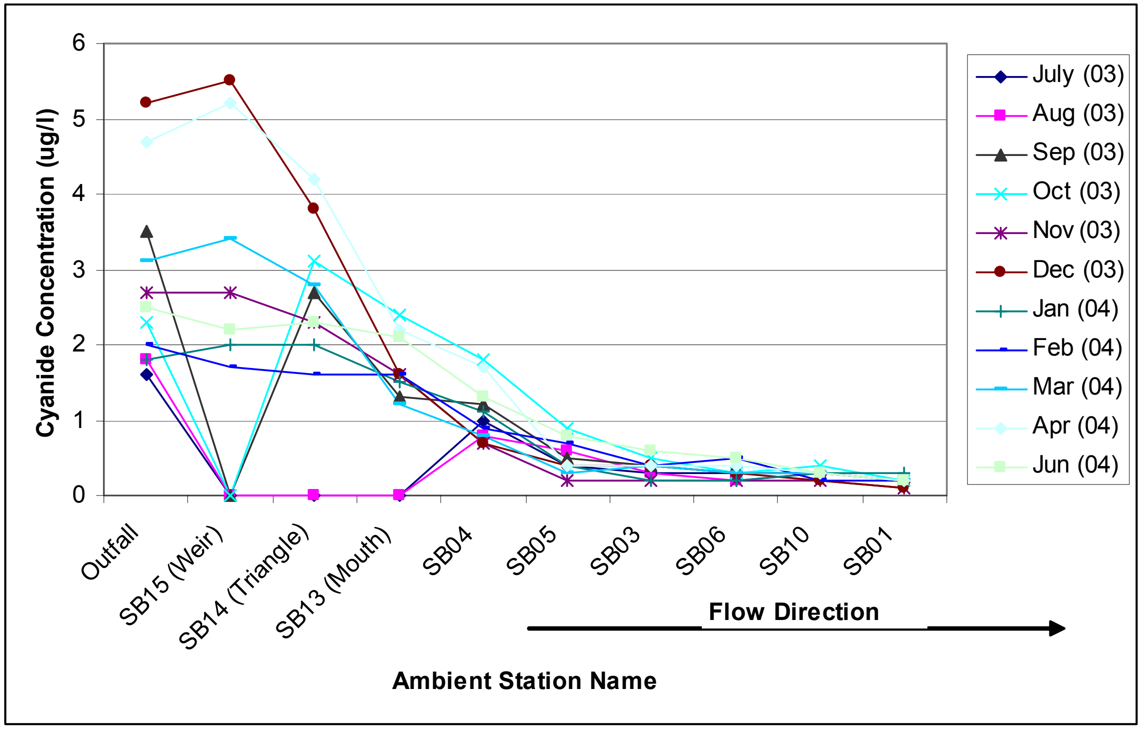
Appendix B

Ambient Cyanide Data

San Jose-Santa Clara Ambient Data (μg/L)

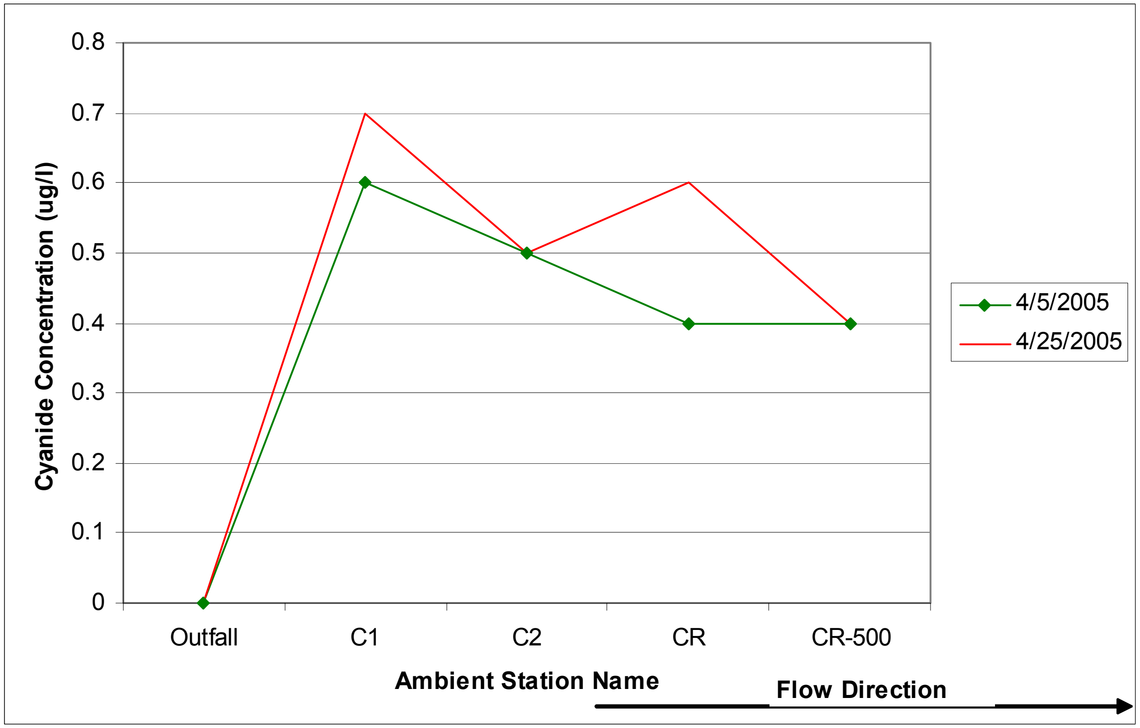
Station	***July (03)***	***Aug (03)***	***Sep (03)***	***Oct (03)***	***Nov (03)***	***Dec (03)***	***Jan (04)***	***Feb (04)***	***Mar (04)***	***Apr (04)***	***Jun (04)***
Outfall	1.6	1.8	3.5	2.3	2.7	5.2	1.8	2	3.1	4.7	2.5
SB15 (Weir)	NS	NS	NS	NS	2.7	5.5	2	1.7	3.4	5.2	2.2
SB14 (Triangle)	NS	NS	2.7	3.1	2.3	3.8	2	1.6	2.8	4.2	2.3
SB13 (Mouth)	NS	NS	1.3	2.4	1.6	1.6	1.5	1.6	1.2	2.2	2.1
SB04	1	0.8	1.2	1.8	0.7	0.7	1.1	0.9	0.8	1.7	1.3
SB05	0.4	0.6	0.5	0.9	0.2	0.4	0.4	0.7	0.3	0.4	0.8
SB03	0.3	0.3	0.4	0.5	0.2	0.4	0.2	0.4	0.4	0.4	0.6
SB06	0.3	0.2	0.3	0.3	0.2	0.3	0.2	0.5	0.3	0.4	0.5
SB07	0.5	0.4	0.3	0.4	0.3	0.4	0.3	0.3	0.4	0.4	0.3
SB02	0.2	0.2	0.3	0.2	0.1	0.2	0.3	0.4	0.2	0.2	0.3
SB08	0.3	0.2	0.3	0.3	0.1	0.1	0.4	0.4	0.2	0.2	0.3
SB10	0.3	0.3	0.3	0.4	0.2	0.2	0.3	0.2	0.3	0.3	0.3
SB09	0.2	0.2	0.3	0.2	0.1	0.3	0.3	0.2	0.2	0.2	0.4
SB01	0.2	0.2	0.2	0.2	0.1	0.1	0.3	0.2	0.2	0.2	0.2
SB11	0.5	0.4	0.6	0.4	0.6	0.9	0.8	0.8	1.1	0.7	0.4
SB12	0.3	0.3	0.3	0.3	0.4	0.5	0.4	0.5	NS	0.5	0.3

San Jose-Santa Clara Ambient Data (μg/L)



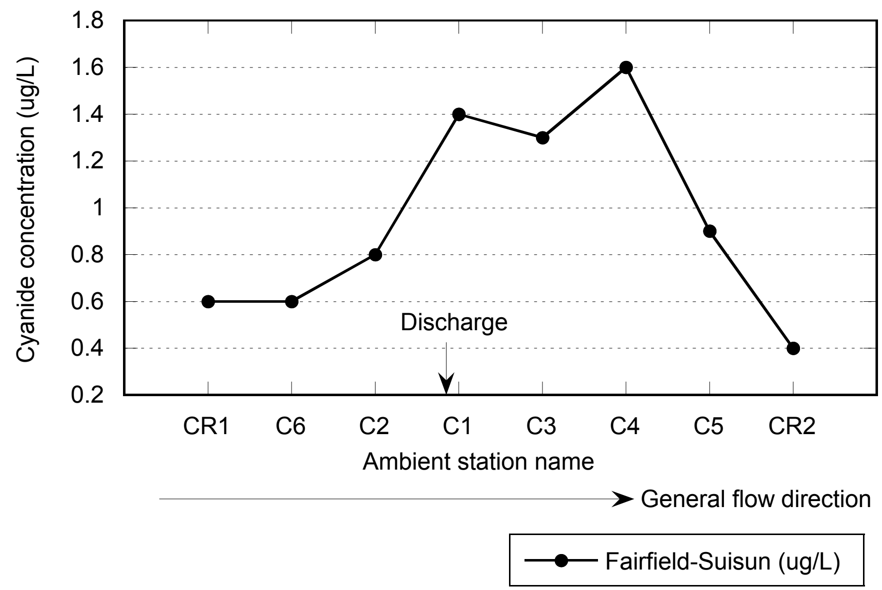
City of American Canyon Ambient Cyanide Data

Site	4/5/2005	4/25/2005
Outfall	<1	<1
C1	0.6	0.7
C2	0.5	0.5
CR	0.4	0.6
CR-500	0.4	0.4



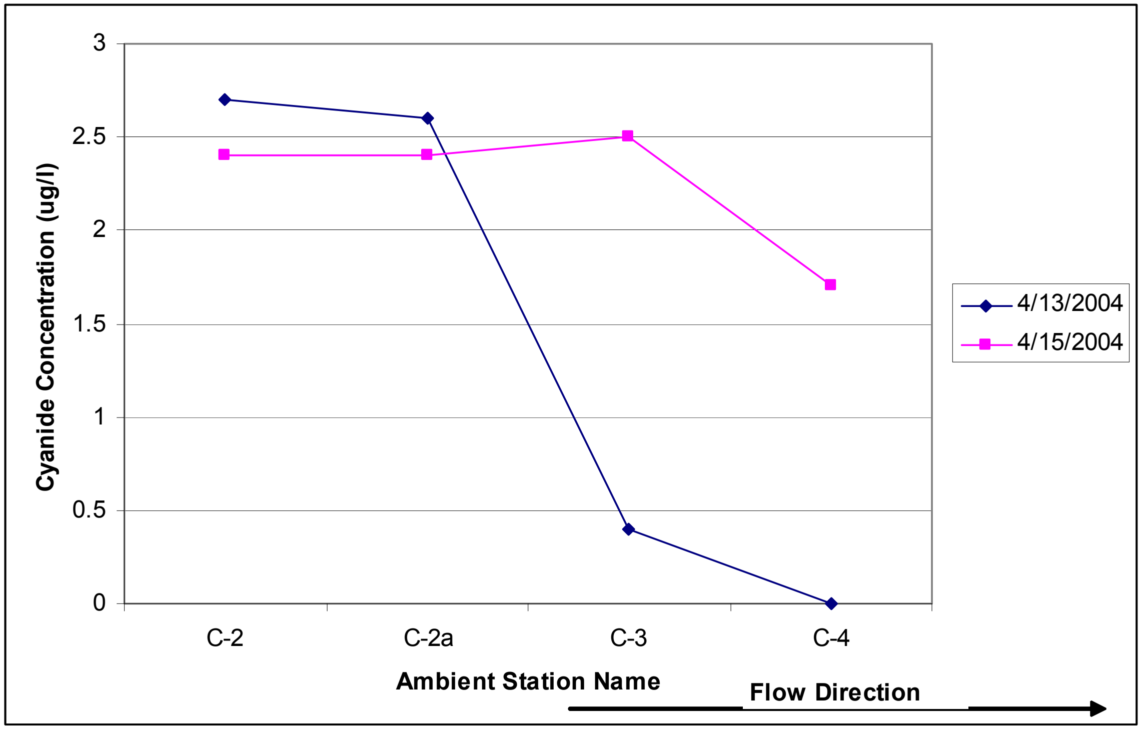
Fairfield-Suisun Sewer District Ambient Cyanide Data, 2/26/04

Station	2/26/04
CR1	0.6
C6	0.6
C2	0.8
C1	1.4
C3	1.3
C4	1.6
C5	0.9
CR2	0.4



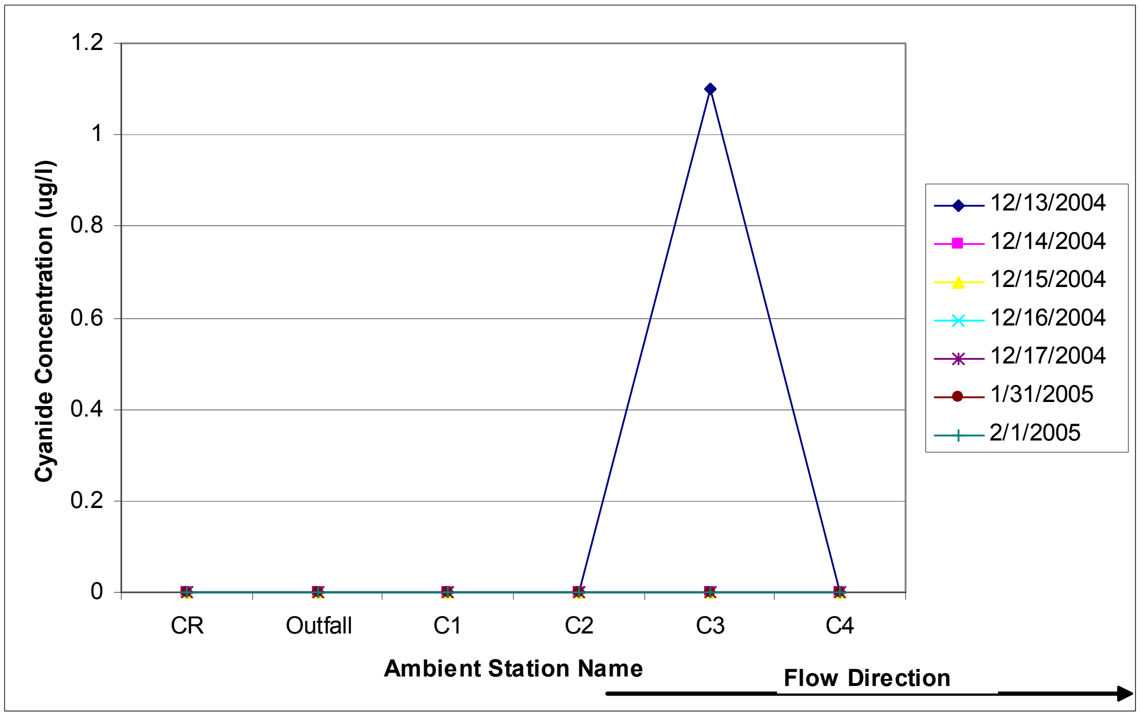
Las Gallinas Sanitatry District Ambient Cyanide Data (μg/L)

Station	4/13/2004	4/15/2004	Minimum	Maximum	Average
C-2	2.7	2.4	2.4	2.7	2.55
C-2a	2.6	2.4	2.4	2.6	2.5
C-3	0.4	2.5	0.4	2.5	1.45
C-4	<0.3	1.7	0.3	1.7	1.7



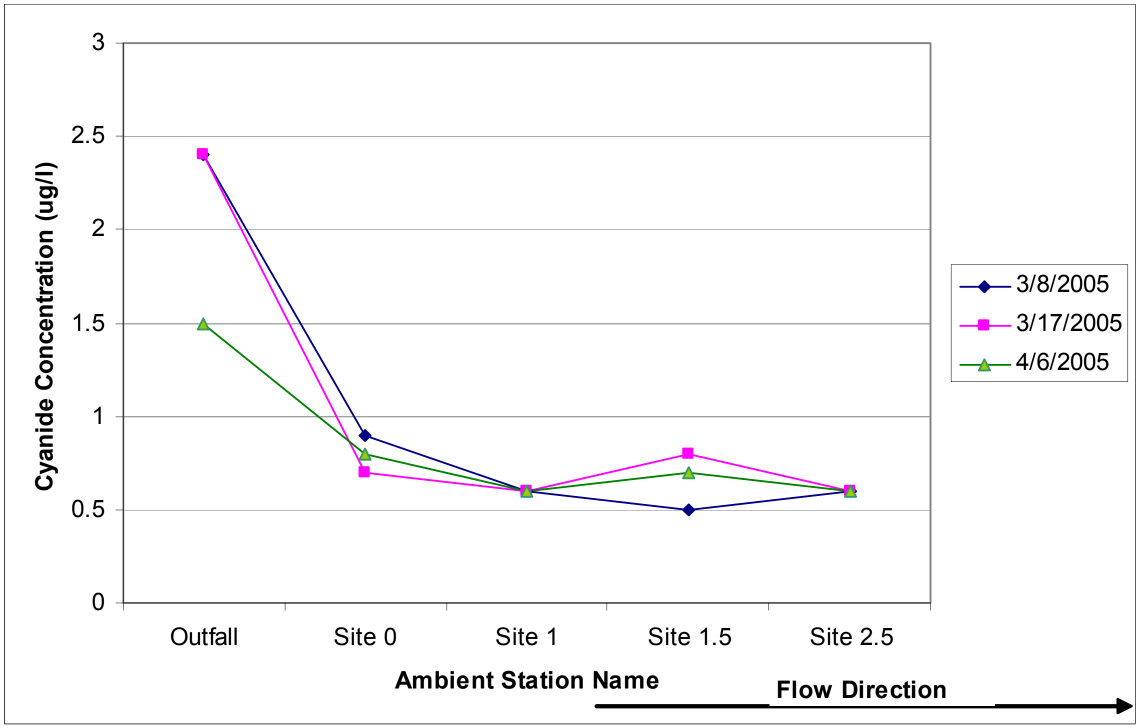
Mountain View Sanitary District Ambient Cyanide Data (μg/L)

Site	12/13/2004	12/14/2004	12/15/2004	12/16/2004	12/17/2004	1/31/2005	2/1/2005
Outfall	<1	<1	<1	<1	<1		
C1	<1						
C2	<1						
C3	1.1					<1	<1
C4	<1						
CR	<1						



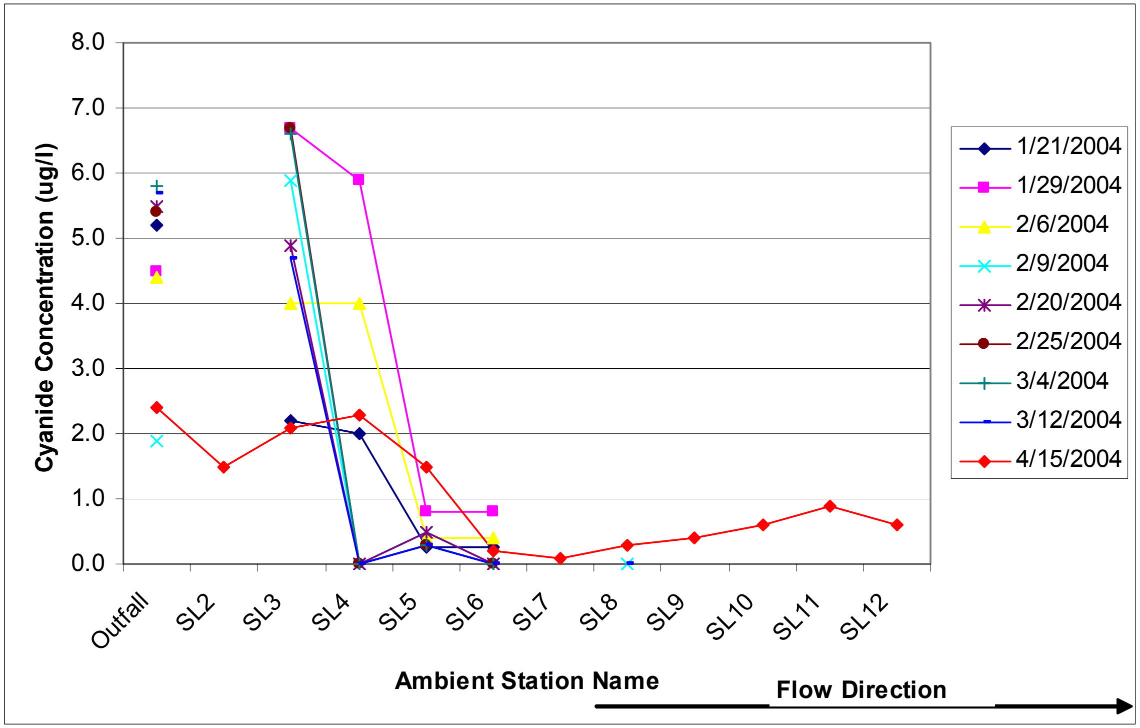
Napa Sanitation District Ambient Cyanide Data (μg/L)

Site	3/8/2005	3/17/2005	4/6/2005
Outfall	2.4	2.4	1.5
Site 0	0.9	0.7	0.80
Site 1	0.6	0.6	0.60
Site 1.5	0.5	0.8	0.70
Site 2.5	0.6	0.6	0.60



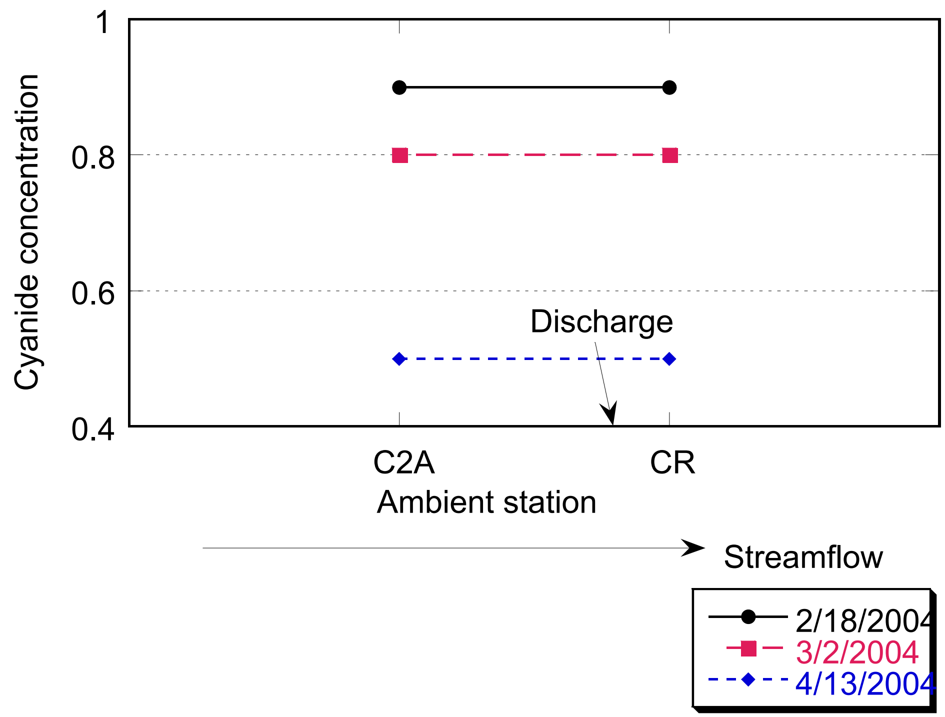
City of Palo Alto Ambient Cyanide Data (μg/L)

Site	1/21/2004	1/29/2004	2/6/2004	2/9/2004	2/20/2004	2/25/2004	3/4/2004	3/12/2004	4/15/2004
Outfall	5.2	4.5	4.4	1.9	5.5	5.4	5.8	5.7	2.4
SL2									1.5
SL3	2.2	6.7	4	5.9	4.9	6.7	6.6	4.7	2.1
SL4	2	5.9	4						2.3
SL5	0.26	0.8	0.4	0.5	0.5	0.3	0.3	0.3	1.5
SL6	0.26	0.8	0.4						0.2
SL7									0.1
SL8									0.3
SL9									0.4
SL10									0.6
SL11									0.9
SL12									0.6



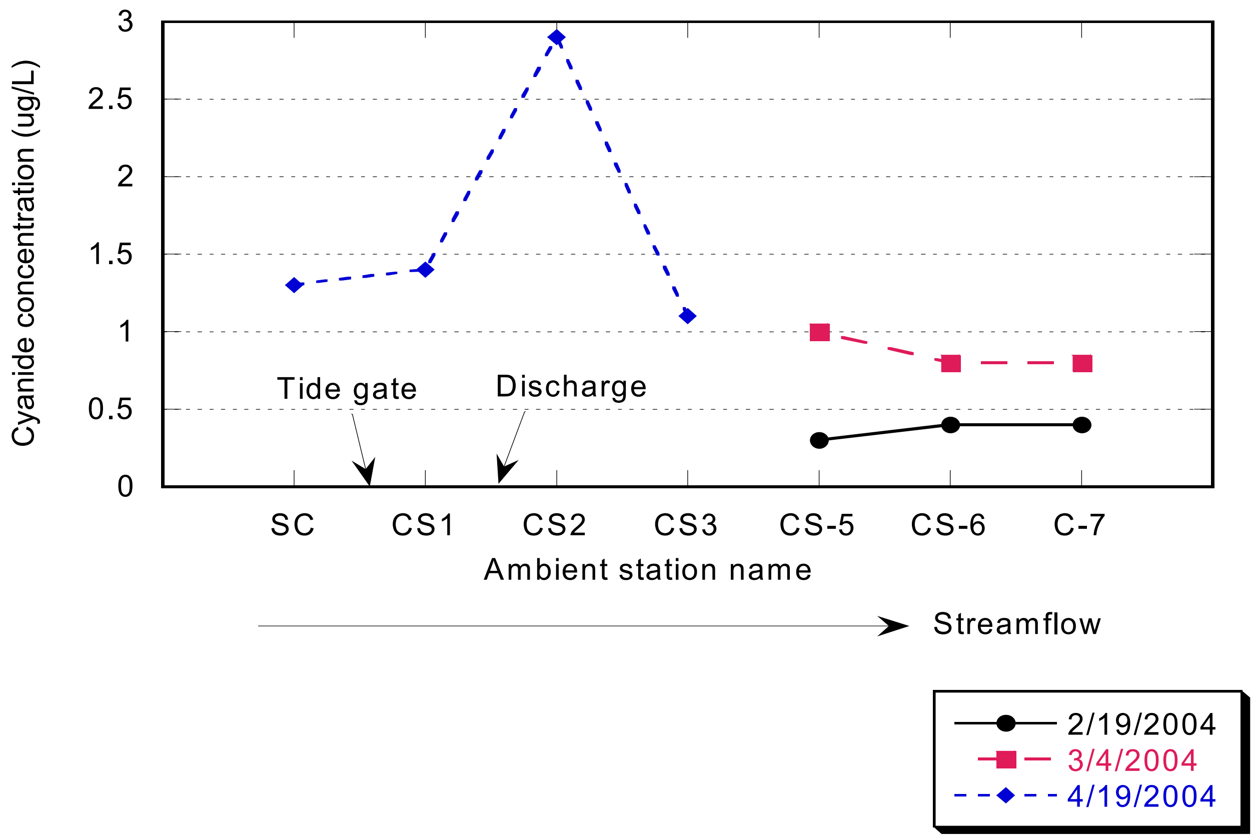
City of Petaluma Ambient Cyanide Data (µg/L)

Station	2/18/04	3/2/04	4/13/04	Minimum	Maximum	Average
C2A	0.9	0.8	0.5	0.5	0.9	0.73
CR	0.9	0.8	0.5	0.5	**0.9**	**0.73**



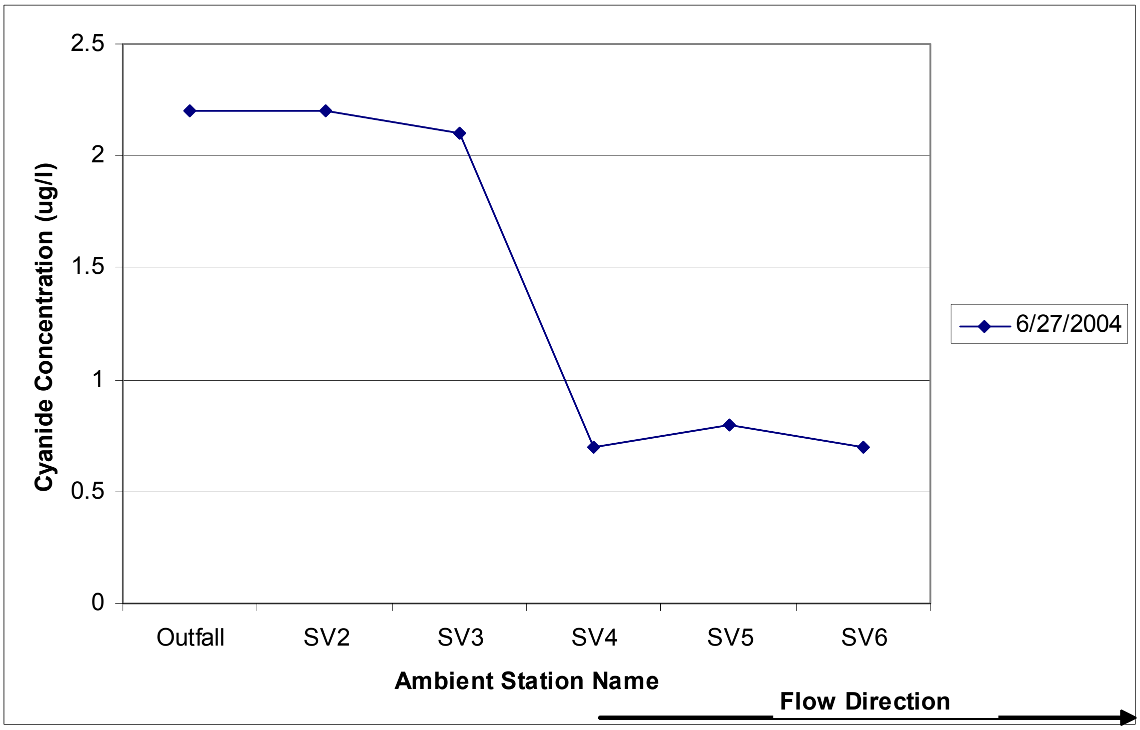
Sonoma County Water Agency Ambient Cyanide Data (μg/L)

Station	2/19/04	3/4/04	4/19/04	Minimum	Maximum	Average
SC			1.3	1.3	1.3	1.30
CS1			1.4	1.4	1.4	1.40
CS2			2.9	2.9	2.9	2.90
CS3			1.1	1.1	1.1	1.10
CS-5	0.3	1		0.3	1	0.65
CS-6	0.4	0.8		0.4	0.8	0.60
C-7	0.4	0.8		0.4	0.8	0.60



City of Sunnyvale Ambient Cyanide Data (μg/L)

Site	6/27/2004
Outfall	2.2
SV2	2.2
SV3	2.1
SV4	0.7
SV5	0.8
SV6	0.7



Appendix C

Discharger Performance Summary

A summary of cyanide effluent concentration data for individual NPDES dischargers is provided below in Table 1. In Table 2, data are summarized by treatment category: (1) municipal secondary treatment facilities, (2) municipal advanced secondary facilities, and (3) industrial facilities. These tables are based on data from the period 2000 to 2004. Effluent data for deep water dischargers was accessed from the Electronic Reporting System (ERS) database, while shallow water discharger data was obtained directly form the dischargers as well as the ERS.

Table 1: Effluent Cyanide Concentrations in Shallow Water NPDES Discharges (2000-2004)

Shallow Water Dischargers[a]	n	%ND*	min (µg/L)	max (µg/L)	median (µg/L)	mean (µg/L)	stdev
American Canyon	15	53.3%	<3	2.9	<3	1.4	0.5
Fairfield-Suisun Sewer District	101	37.6%	<0.9	28	3.0	3.9	0.8
Hayward Marsh	33	54.5%	<3	11.3	<3	2.9	0.7
USD discharge into Hayward Marsh	48	66.7%	,<3	24	<3	2.4	1.1
Las Gallinas Valley SD	20	55.0%	<3	10	<3	3.0	0.7
Mt. View Sanitary District	22	81.8%	<3	1.6	<3	0.5	0.6
Napa Sanitation District	54	72.2%	<0.3	20	<3	2.6	1.0
Novato Sanitation District	24	50.0%	<0.9	4.4	1.6	1.8	0.6
Palo Alto, City of	77	53.2%	<1.6	10	<3	3.3	0.3
Petaluma, City of	27	44.4%	<3	10	1.6	2.9	0.8
San Jose Santa Clara WPCP*	11	0%	1.6	5.2	2.5	5.1	0.4
Sonoma Valley County Water Agency	44	77.3%	<3	13	<5	3.2	0.7
Sunnyvale, City of	80	70.0%	<5	29	<5	4.4	0.8

1. Averages were calculated using the probability regression method
2. Non-detects (NDs) are considered smaller than those detected values when determining the minimum and median
* 2003 – 2004 data values were used for this summary. All other discharger summaries use data from 2000-2003.

Table 2: Effluent Cyanide Concentrations in Deep Water NPDES Discharges (2000- 2004)[1]

Deep Water Dischargers	n	%ND*	min (µg/L)	max (µg/L)	median (µg/L)	mean (µg/L)	stdev
Benicia, City of	48	14.6%	0.9	26.0	4.0	5.6	5.1
Burlingame, City of	58	31.0%	0.9	13.0	3.0	3.3	2.0
Central Contra Costa Sanitary District	45	44.4%	2.0	9.9	3.1	3.8	1.7
Central Marin Sanitation Agency	47	29.8%	0.6	16.0	3.0	4.3	2.9
Chevron Richmond Refinery	32	46.9%	3.0	14.9	10.0	7.3	3.7
ConocoPhillips (at Rodeo)	52	53.8%	3.0	14.0	5.0	6.1	2.4
Delta Diablo Sanitation District	45	82.2%	1.0	13.0	6.0	7.1	3.1
Dow Chemical Company	26	80.8%	0.9	5.7	3.0	3.3	1.4
Dublin San Ramon Services District	51	98.0%	7.0	8.8	7.0	7.0	0.3
EBDA	186	58.6%	3.0	68.0	3.0	5.1	8.1
EBMUD	101	18.8%	0.0	25.0	4.0	5.7	4.3
GWF E 3rd St (Site I)	17	88.2%	5.0	10.0	7.0	7.5	2.5
GWF Nichols Rd (Site V)	16	100.0%	3.0	10.0	7.5	7.4	2.8
Livermore, City of	7	100.0%	3.0	25.0	18.0	14.9	9.1
Martinez Refining Company	129	0.0%	4.0	29.0	13.0	13.2	5.7
Millbrae, City of	47	48.9%	0.6	18.0	3.0	3.7	2.6
Morton	6	100.0%	2.0	10.0	10.0	7.5	3.9
North San Mateo	15	93.3%	5.0	50.0	10.0	17.3	17.0
Pacifica Calera Creek	33	48.5%	1.0	60.0	3.0	4.8	10.0

Pinole-Hercules	28	64.3%	0.9	10.0	3.0	3.5	1.6
Rhodia Basic Chemicals	14	100.0%	10.0	10.0	10.0	10.0	0.0
Rodeo Sanitary District	20	65.0%	1.9	7.0	3.0	3.7	1.2
S.F. Airport, Water Quality Control Plant	48	89.6%	3.0	16.5	10.0	9.8	1.9
S.F.Airport, Industrial	145	98.6%	3.0	10.0	10.0	9.8	1.1
S.F.City & County Southeast, North Point & Bayside	113	75.2%	0.2	10.0	10.0	7.8	3.6
Sewer Authority Mid-Coastside	4	100.0%	5.0	10.0	10.0	8.8	2.5
San Francisco Oceanside	33	100.0%	10.0	10.0	10.0	10.0	0.0
San Mateo, City of	42	66.7%	3.0	15.0	3.0	4.3	2.2
Sausalito-Marin Sanitary District	41	4.9%	1.6	20.0	9.0	9.6	4.7
South Bayside System Authority	101	48.5%	1.1	14.7	10.0	7.8	3.0
South San Francisco & San Bruno	105	32.4%	3.0	430.0	8.0	18.3	45.1
Tiburon Treatment Plant	9	88.9%	5.0	5.0	5.0	5.0	0.0
Tesoro Golden Eagle Refinery	173	54.9%	3.0	28.0	10.0	8.8	4.1
US Navy Treasure Island	11	100.0%	10.0	10.0	10.0	10.0	0.0
USS - Posco	36	100.0%	5.0	10.0	10.0	8.8	2.2
Valero Benicia Refinery	166	97.6%	10.0	15.0	10.0	10.0	0.4
Vallejo San & Flood Control District	36	72.2%	3.0	22.8	3.0	4.8	5.0
West County/Richmond	12	8.3%	0.9	8.0	3.5	3.6	2.0

*when sample was reported as "not detected", summary statistics were performed assuming the concentration = detection limit.

[1]Data used to compile this summary were taken from discharger-recorded data between the time period of January 2000 – April 2004; The summary represents available data from this time period rather than a continuous summary of that time period.

Table 3: Effluent Cyanide Concentrations by Facility Category

	Advanced Secondary	Secondary	Industrial
n	440	1182	869
min (μg/L)	0.3	0.003	0.9
max (μg/L)	29	430	29
median (μg/L)	5	4.75	10
mean (μg/L)	5.6	7.1	9.3
stdev	3.4	14.8	3.9

Cyanide effluent data are shown graphically in Figures 1 through 5. Figures 1 through 3 portray effluent data for individual facilities in "box and whisker" plots. These plots show the full data set for each facility (10th percentile, 25th percentile, 50th percentile, 75th percentile and 90th percentile) and are grouped by facility category. Figure 4 shows the pooled results for all facilities in the three treatment categories. Figure 5 depicts the pooled probability plots for each of the three treatment categories.

Figure 1: Maximum Daily Effluent Cyanide: Secondary Dischargers (2000 - 2004)

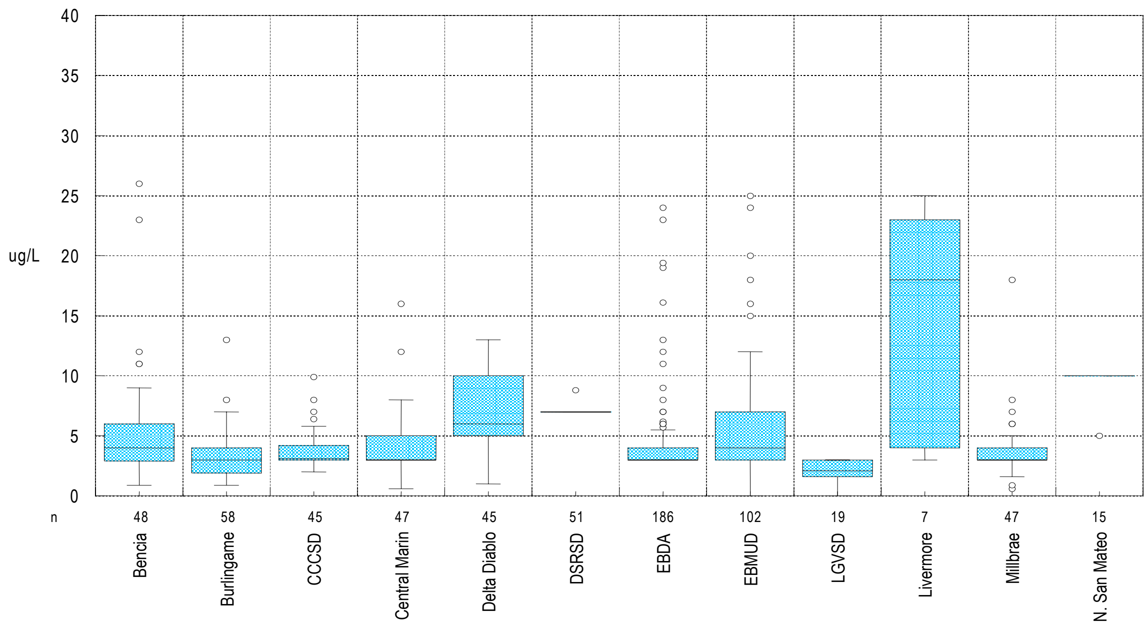


Figure 1, continued: Maximum Daily Effluent Cyanide: Secondary Dischargers (2000 - 2004)

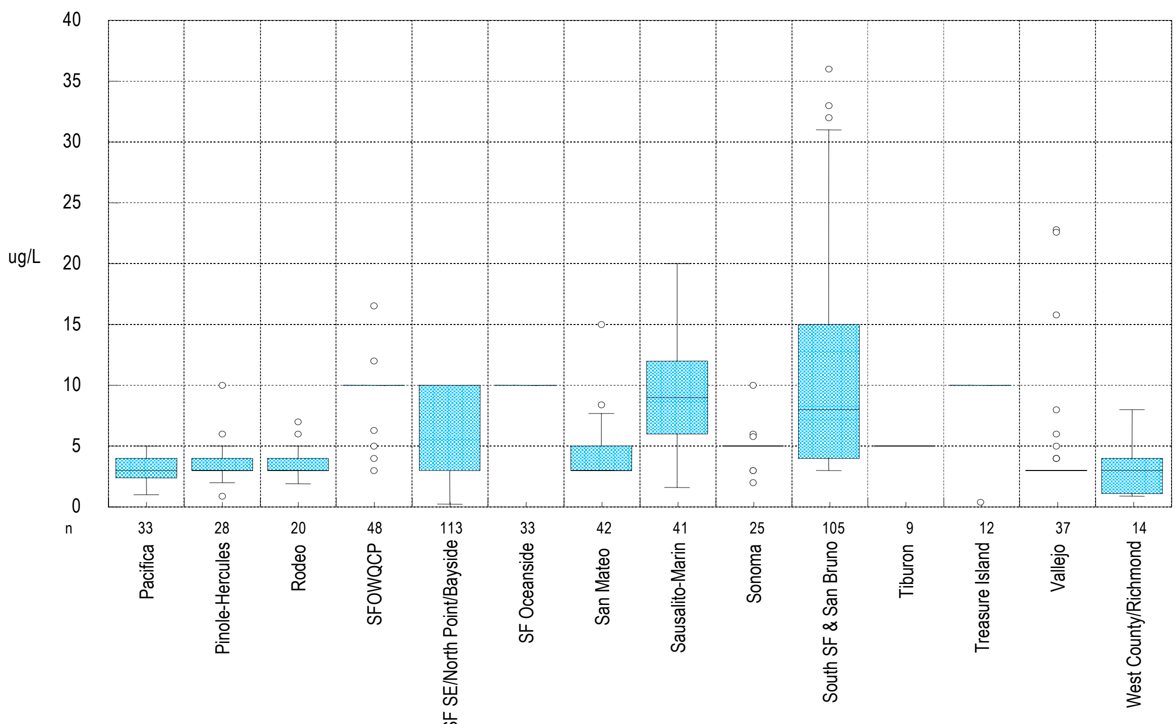


Figure 2: Maximum Daily Effluent Cyanide: Advanced Secondary Dischargers (2000 - 2004)

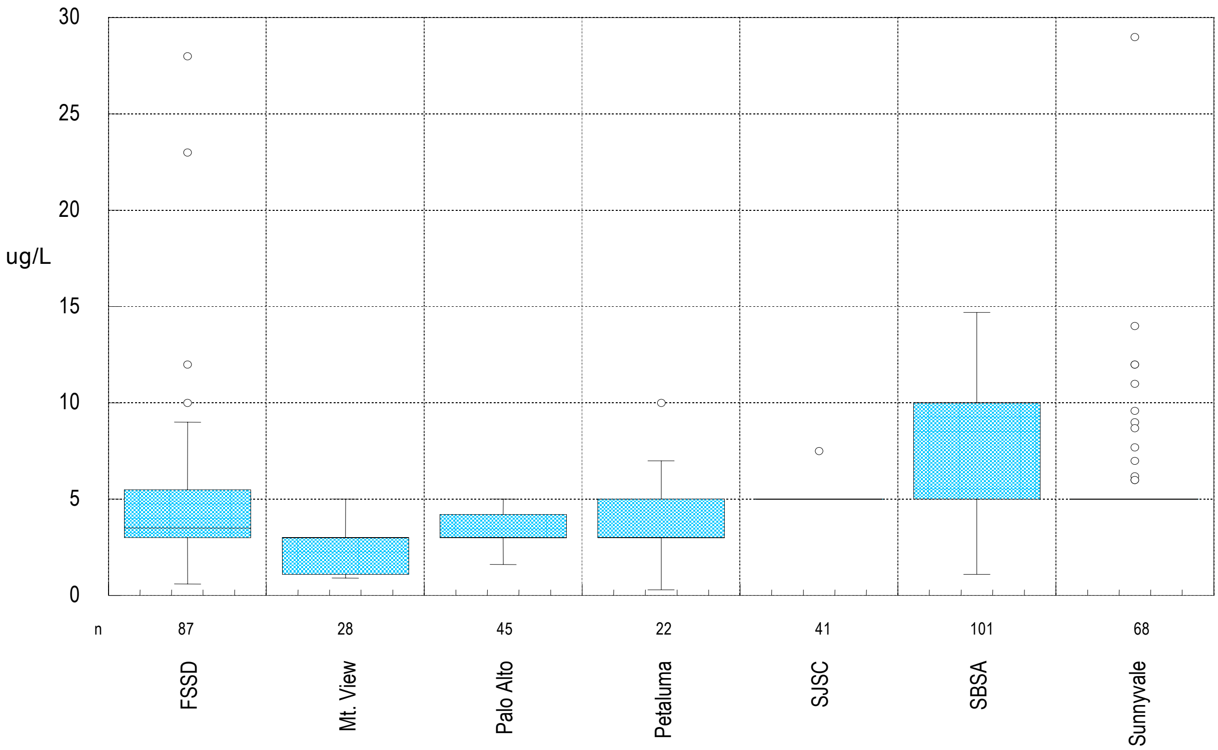


Figure 3: Maximum Daily Effluent Cyanide; Industrial Dischargers (2000 - 2004)

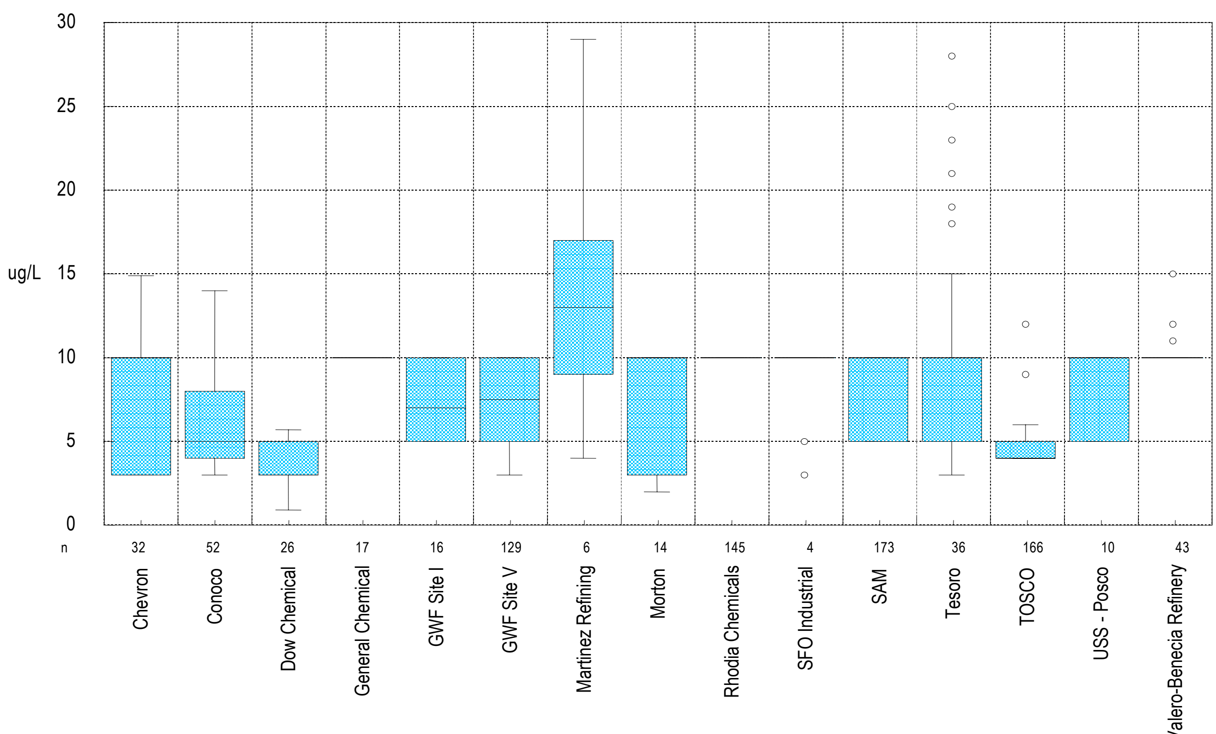
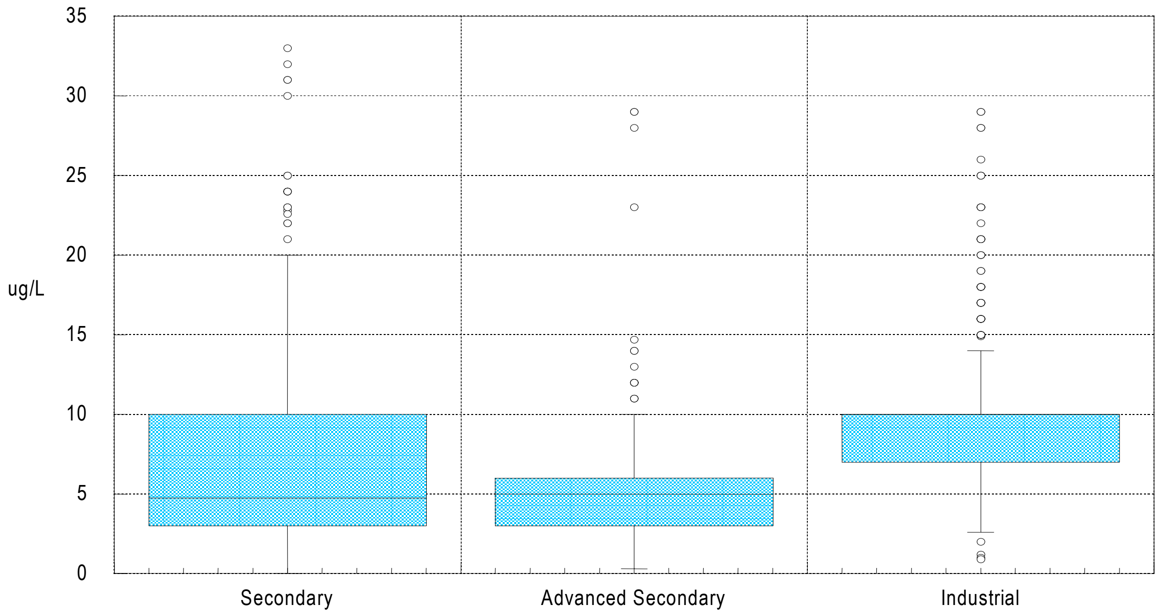
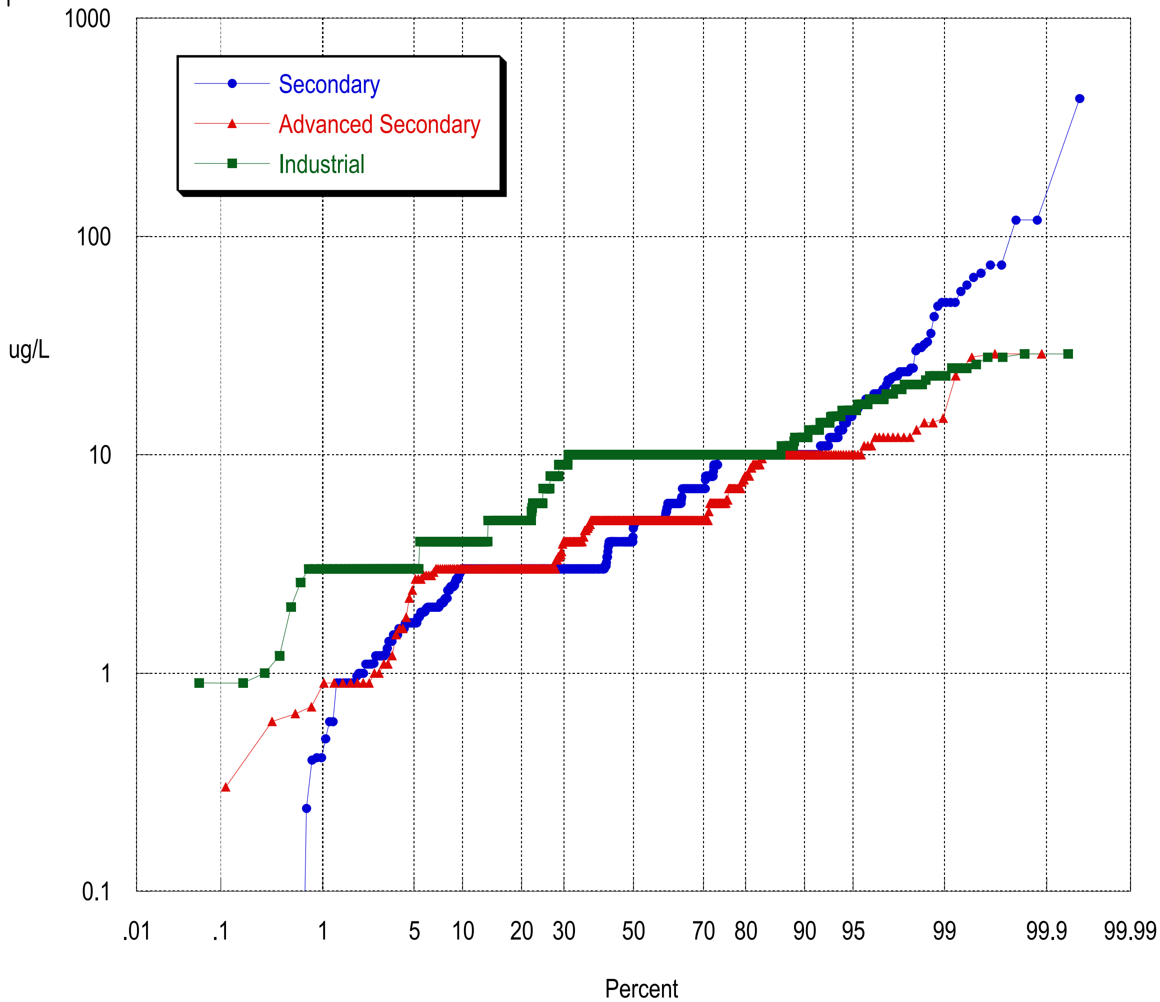


Figure 4: Effluent Cyanide Concentrations by Facility Category (2000 – 2004)



	Secondary	Advanced Secondary	Industrial
n	1182	440	869
min	0.003	0.3	0.9
max	430	29	29
median	4.75	5	10
mean	7.1	5.6	9.3
stdev	14.8	3.4	3.9

Figure 5: Maximum Daily Effluent Cyanide (2000 - 2004)

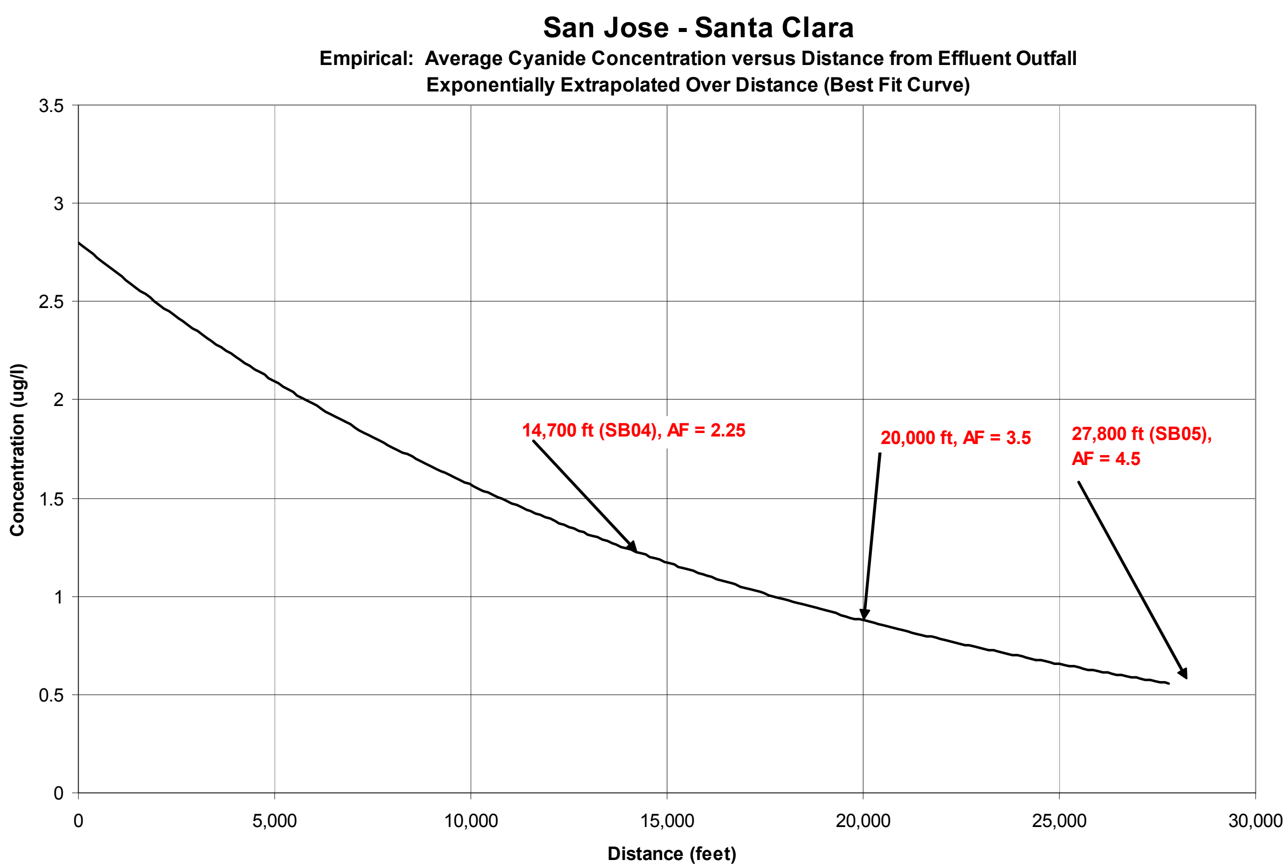


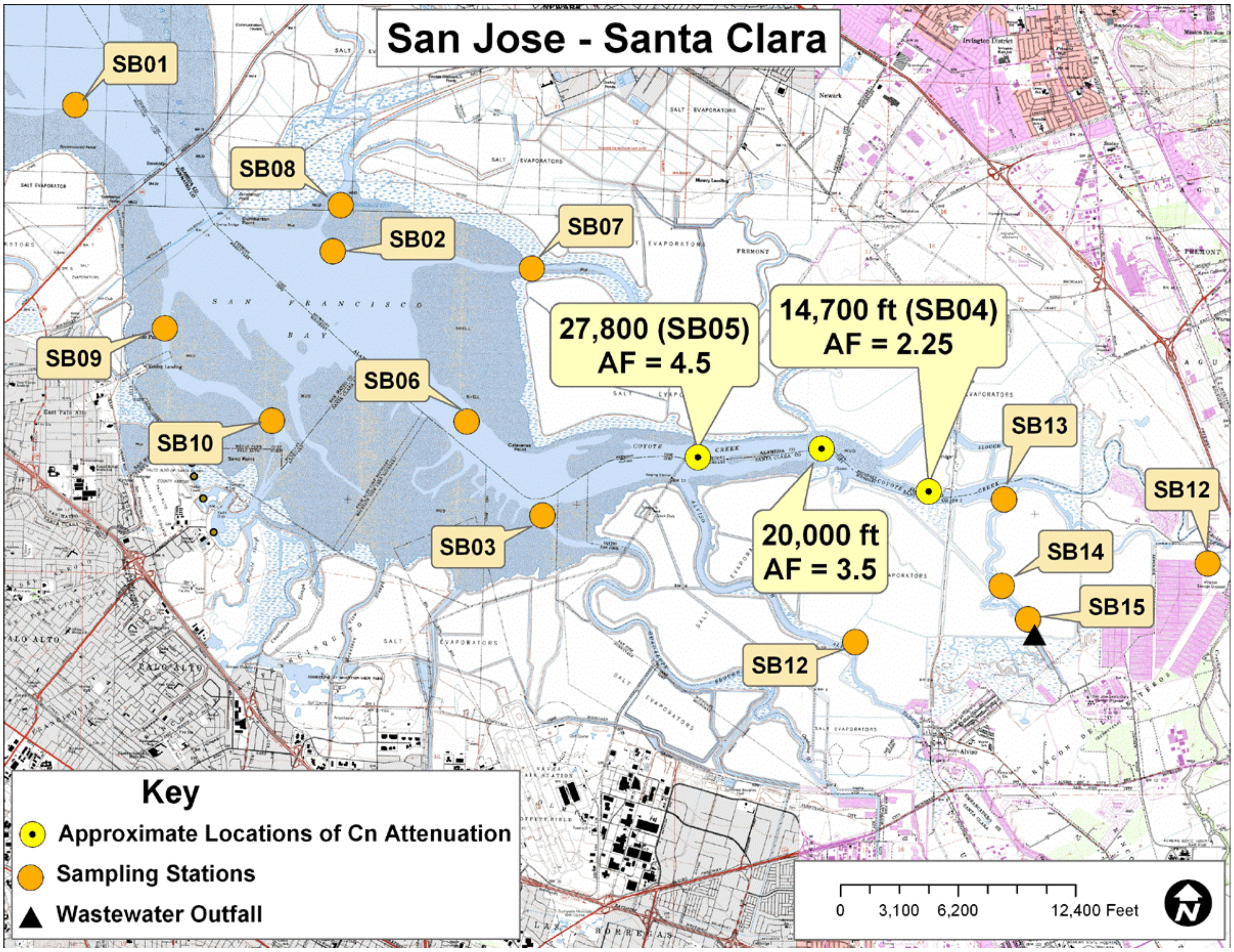
Appendix D

Spatial Descriptions of Effluent Attenuation

San Jose – Santa Clara

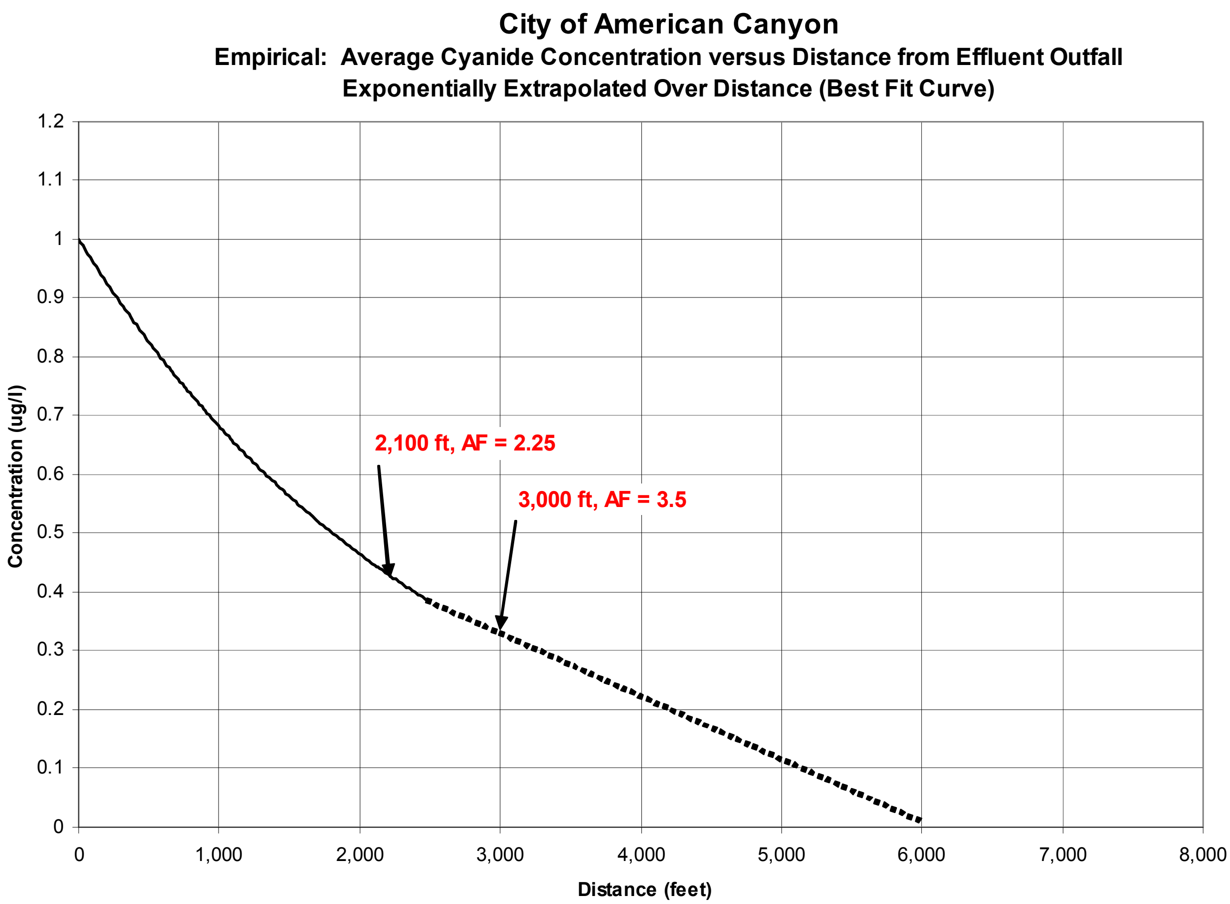
Site	Average Cyanide ug/l	No. data points	Distance from Outfall		Surface Water Area Between Sites		Median AF
			feet	kilometers	acres	sq. kilometer	
San Jose - Santa Clara							
Outfall	2.80	11	0	0	0		1
SB15 (Weir)	3.24	11	1,300	0.4	5	0.0	0.9
SB14 (Triangle)	2.76	11	7,200	2.2	26	0.10	1.1
SB13 (Mouth)	1.72	11	13,000	4.0	35	0.14	1.7
SB04	1.09	11	14,700	4.5	50	0.20	**2.25**
Attenuation	-	-	20,000	6.1	200	0.8	**3.5**
SB05	0.51	11	27,800	8.5	500	2.0	**4.5**
SB12	0.38	11	28,100	8.6	288	1.1	7.2
SB03	0.37	11	36,900	11.2	1,350	5.3	7.8
SB06	0.32	11	40,100	12.2	2,750	10.9	9.0
SB07	0.36	11	48,100	14.7	6,650	26.3	7.8
SB10	0.28	11	50,100	15.3	4,500	17.8	10.0
SB02	0.24	11	52,100	15.9	8,450	33.4	11.5
SB08	0.25	11	53,600	16.3	9,400	37.2	9.0
SB09	0.24	11	57,100	17.4	6,000	23.7	11.5
SB01	0.19	11	67,100	20.5	10,100	39.9	12.5

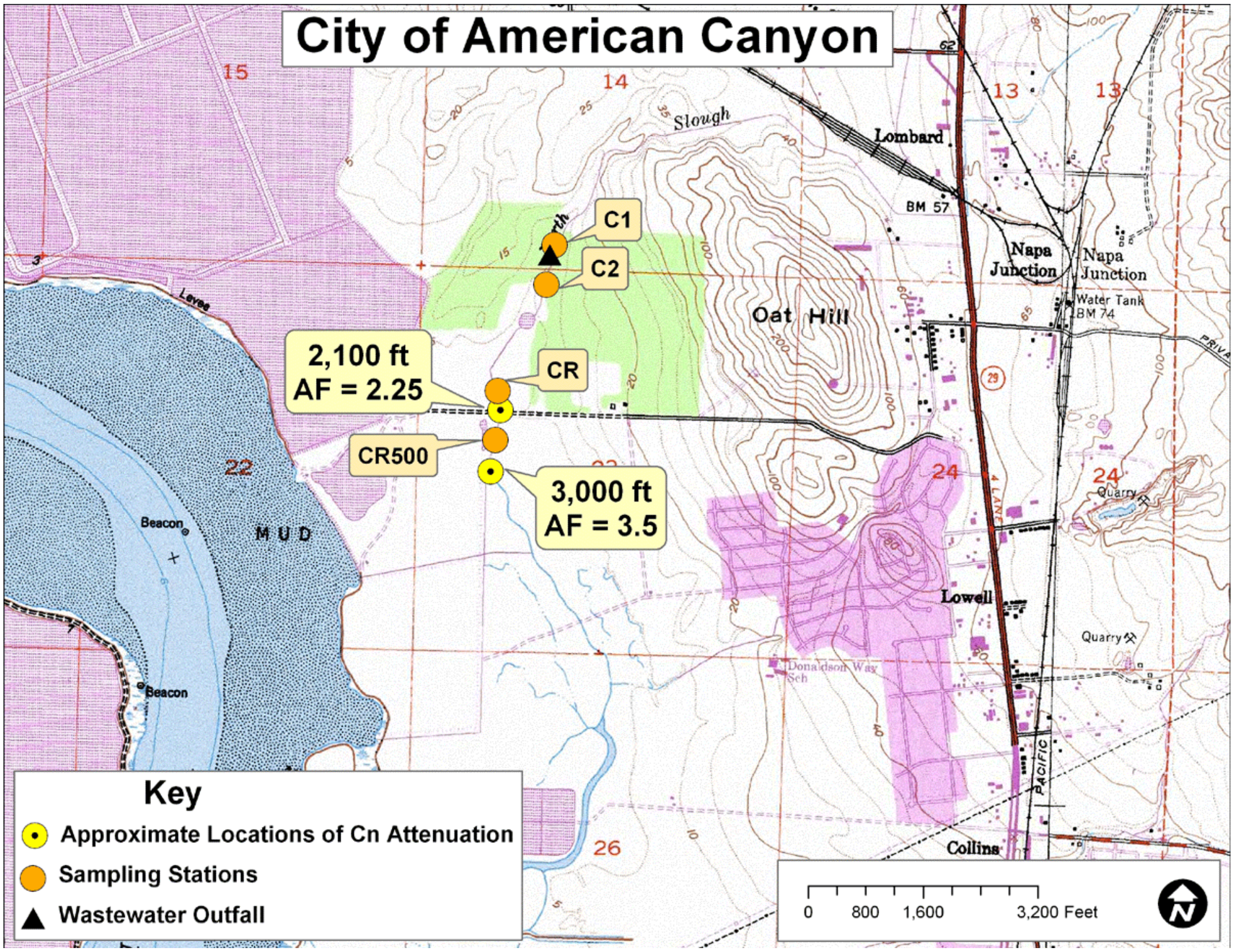



San Jose - Santa Clara
SB01
SB08
SB02
SB07
SB09
SB06
SB10
SB03
27,800 (SB05)
AF = 4.5
14,700 ft (SB04)
AF = 2.25
20,000 ft
AF = 3.5
SB13
SB12
SB14
SB15
SB12
Key
Approximate Locations of Cn Attenuation
Sampling Stations
Wastewater Outfall
0
3,100
6,200
12,400 Feet

City of American Canyon

Site	Average Cyanide ug/l	No. data points	Distance from Outfall		Surface Water Area Between Sites		Median AF
			feet	kilometers	acres	sq. kilometer	
American Canyon							
C1	0.65	2	-20	0.0	0	0	-
Outfall	1	2	0	0.0	0	0.000	1
C2	0.5	2	500	0.2	0.34	0.001	2
CR	0.5	2	2,000	0.6	1.38	0.005	2.10
Attenuation	-	-	2,100	0.6	1.45	0.006	**2.25**
CR500	0.4	2	2,500	0.8	2.87	0.011	2.5
Attenuation	-	-	3,000	0.91	3.44	0.014	**3.5**



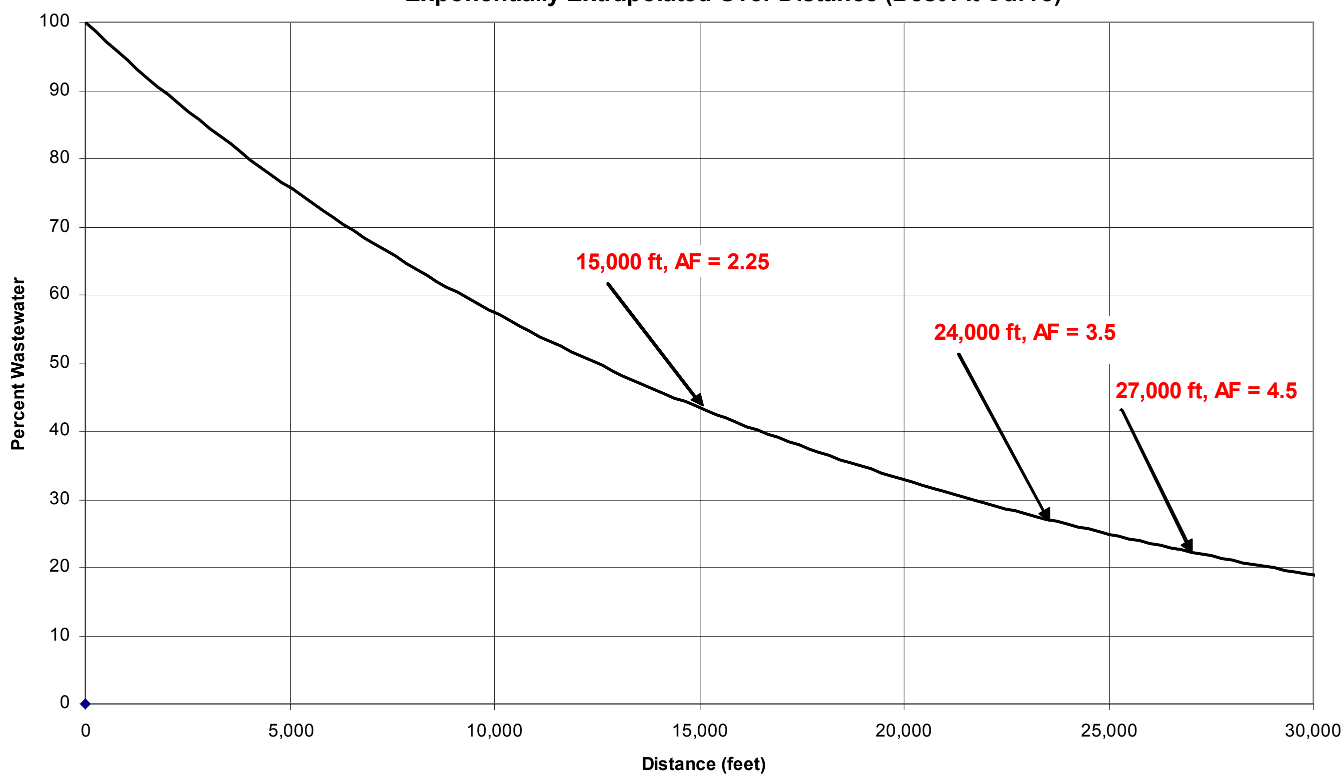

City of American Canyon
C1
C2
CR
2,100 ft
AF = 2.25
CR500
3,000 ft
AF = 3.5
Key
Approximate Locations of Cn Attenuation
Sampling Stations
Wastewater Outfall
0
800
1,600
3,200 Feet
Oat Hill
Napa Junction
Lombard
Lowell
Collins
MUD
Beacon
Slough
Levee
Quarry
Water Tank
BM 74
BM 57
Donaldson Way Sch
PACIFIC
4 LANE
N

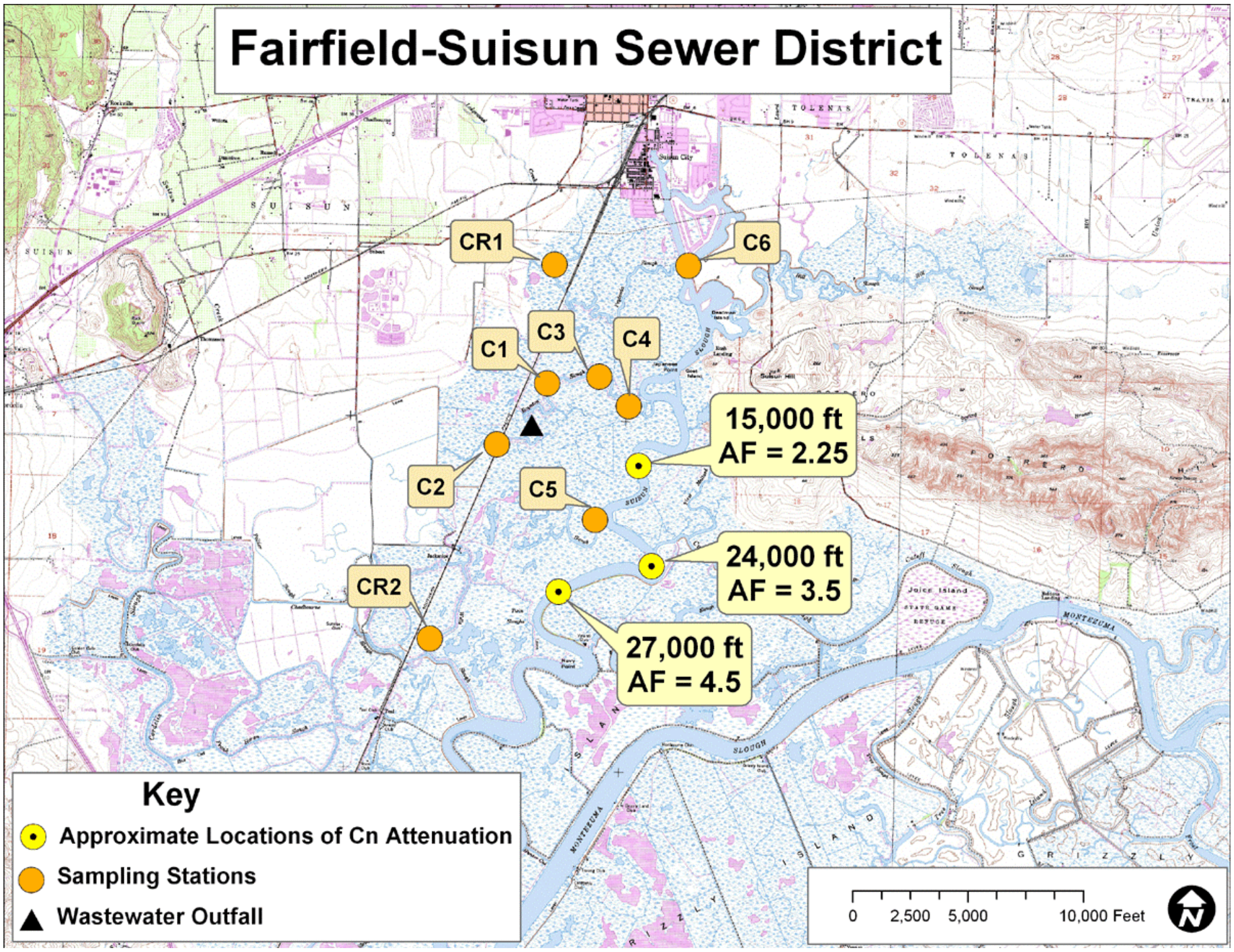
Fairfield-Suisun Sewer District

Site	Cyanide ug/l	No. data points	Distance from Outfall		Surface Water Area Between Sites		AF†
			feet	kilometers	acres	sq. kilometer	
Faiefield - Suisun							
C2	0.8	1	-100	0	0.2	0.000	-
Outfall	1.4	1	0	0	0	0.000	1
C1	1.4	1	100	0.0	0.20	0.001	1
C3	1.3	1	1,800	0.5	3.5	0.01	1.1
C4	1.6	1	10,000	3.0	4.3	0.02	0.9
Attenuation	-	-	15,000	4.6	5.8	0.02	**2.25**
C5	0.9	1	21,000	6.4	24.5	0.10	1.6
C6	0.6	1	29,500	9.0	32.0	0.13	2.3
CR1	0.6	1	32,200	9.8	34.4	0.14	2.3
Attenuation	-	-	24,000	7.32	28.0	0.11	**3.5**
Attenuation	-	-	27,000	8.23	32.1	0.13	**4.5**
CR2	0.4	1	45,000	13.72	48.0	0.19	3.5

† Attenuation Factors in bold were derived from modeled percent wastewater, AF numbers not in bold are the median AF derived using empirical data.

Fairfield - Suisun SD
Modeled Percent Wastewater versus Distance from Effluent Outfall
Exponentially Extrapolated Over Distance (Best Fit Curve)

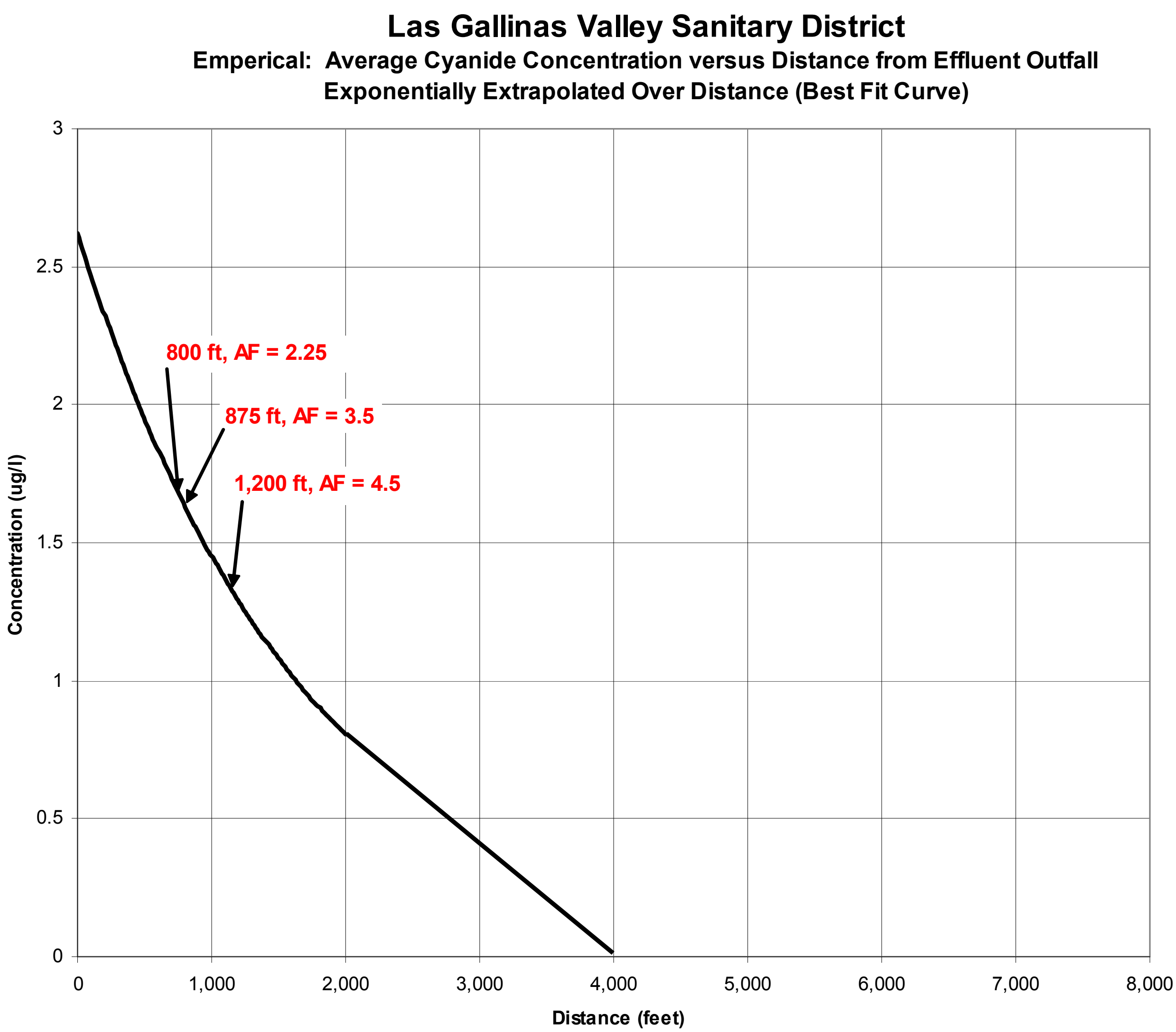


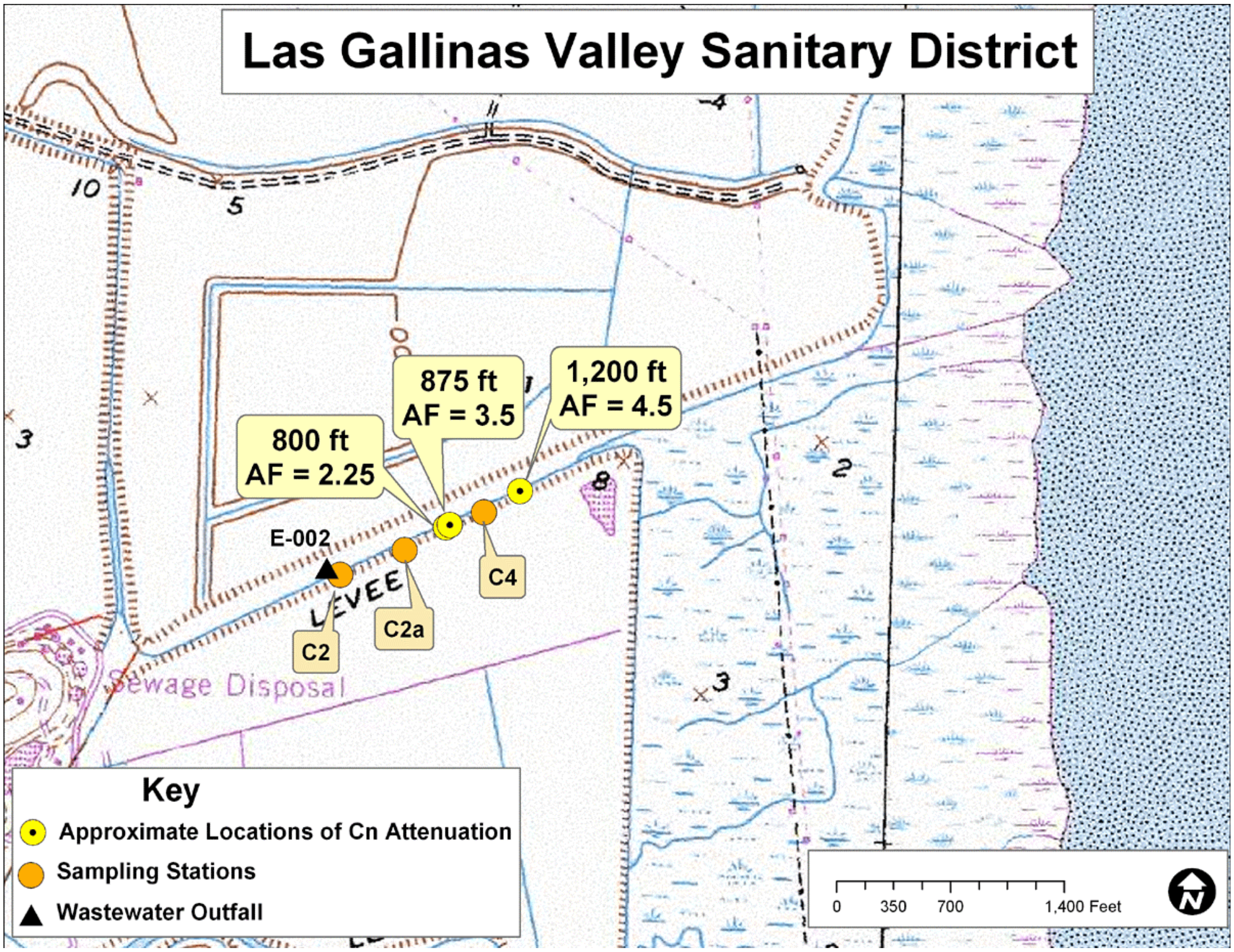

Fairfield-Suisun Sewer District
CR1
C6
C3
C1
C4
15,000 ft
AF = 2.25
C2
C5
24,000 ft
AF = 3.5
CR2
27,000 ft
AF = 4.5
Key
Approximate Locations of Cn Attenuation
Sampling Stations
Wastewater Outfall
0 2,500 5,000 10,000 Feet

Las Gallinas Valley Sanitary District

Site	Average Cyanide ug/l	No. data points	Distance from Outfall		Surface Water Area Between Sites		Median AF†
			feet	kilometers	acres	sq. kilometer	
Las Gallinas							
Outfall	0.6	2	0	0	0	0.000	1
C2	2.625	2	20	0.0	0.0	0.000	0
C2a	2.1	2	50	0.0	0.0	0.000	1.3
Attenuation	-	-	800	0.2	1.0	0.004	**2.25**
Attenuation	-	-	875	0.27	1.1	0.004	**3.5**
Attenuation	-	-	1,200	0.37	2.8	0.004	**4.5**
C4	1.025	2	2000	0.61	4.4	0.011	5.2

†Average Cyanide concentration at station C2 was used as outfall to calculate Attenuation Factors

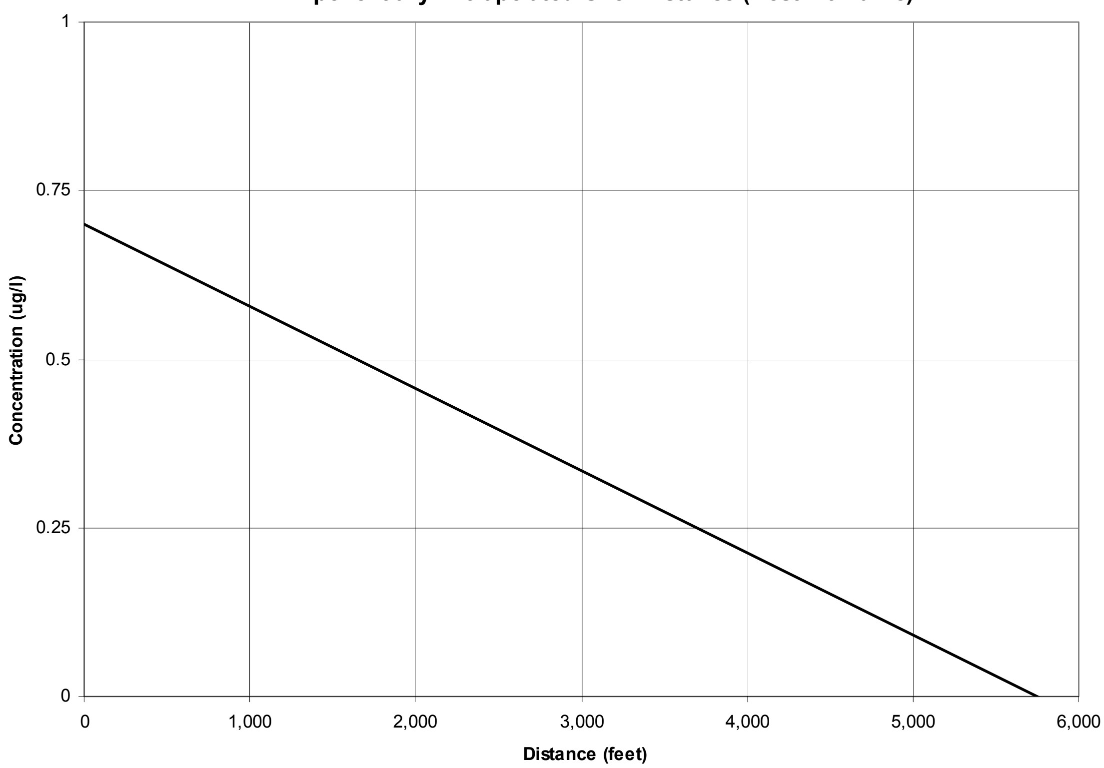



Las Gallinas Valley Sanitary District
800 ft
AF = 2.25
875 ft
AF = 3.5
1,200 ft
AF = 4.5
E-002
C2
C2a
C4
LEVEE
Sewage Disposal
Key
Approximate Locations of Cn Attenuation
Sampling Stations
Wastewater Outfall
0
350
700
1,400 Feet

Mt. View Sanitary District

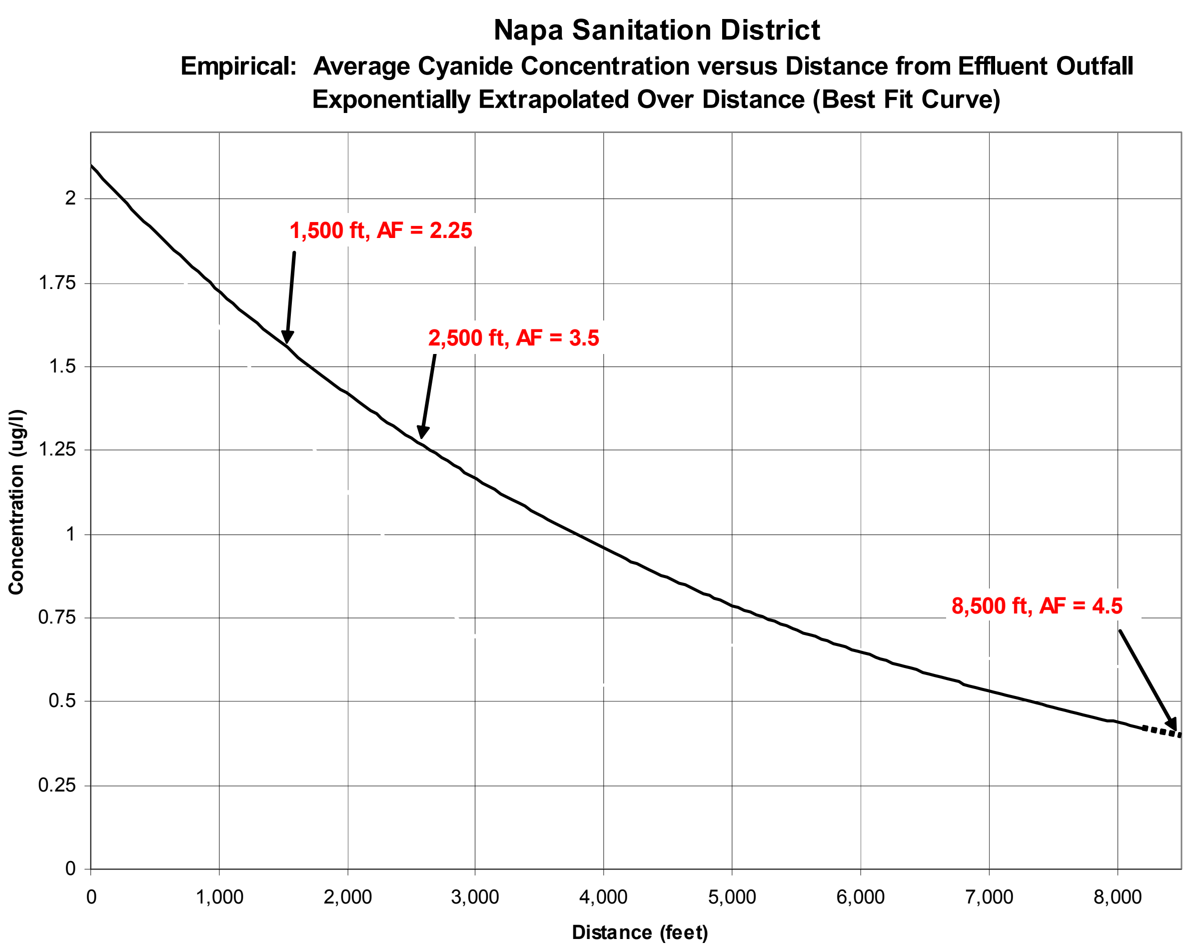
Site	Average Cyanide ug/l	No. data points	Distance from Outfall		Surface Water Area Between Sites		Median AF
			feet	kilometers	acres	sq. kilometer	
Mt. View Sanitary District							
CR	<1	1	-800	0	0.1	0.00	0
Outfall	<1	5	0	0	0	0.00	0
C1	<1	1	10	0.0	0	0.00	0
C2	<1	1	600	0.2	0.1	0.00	0
C3	0.7	3	1,800	0.5	0.8	0.00	0
C4	<1	1	6,000	1.8	2	0.01	0

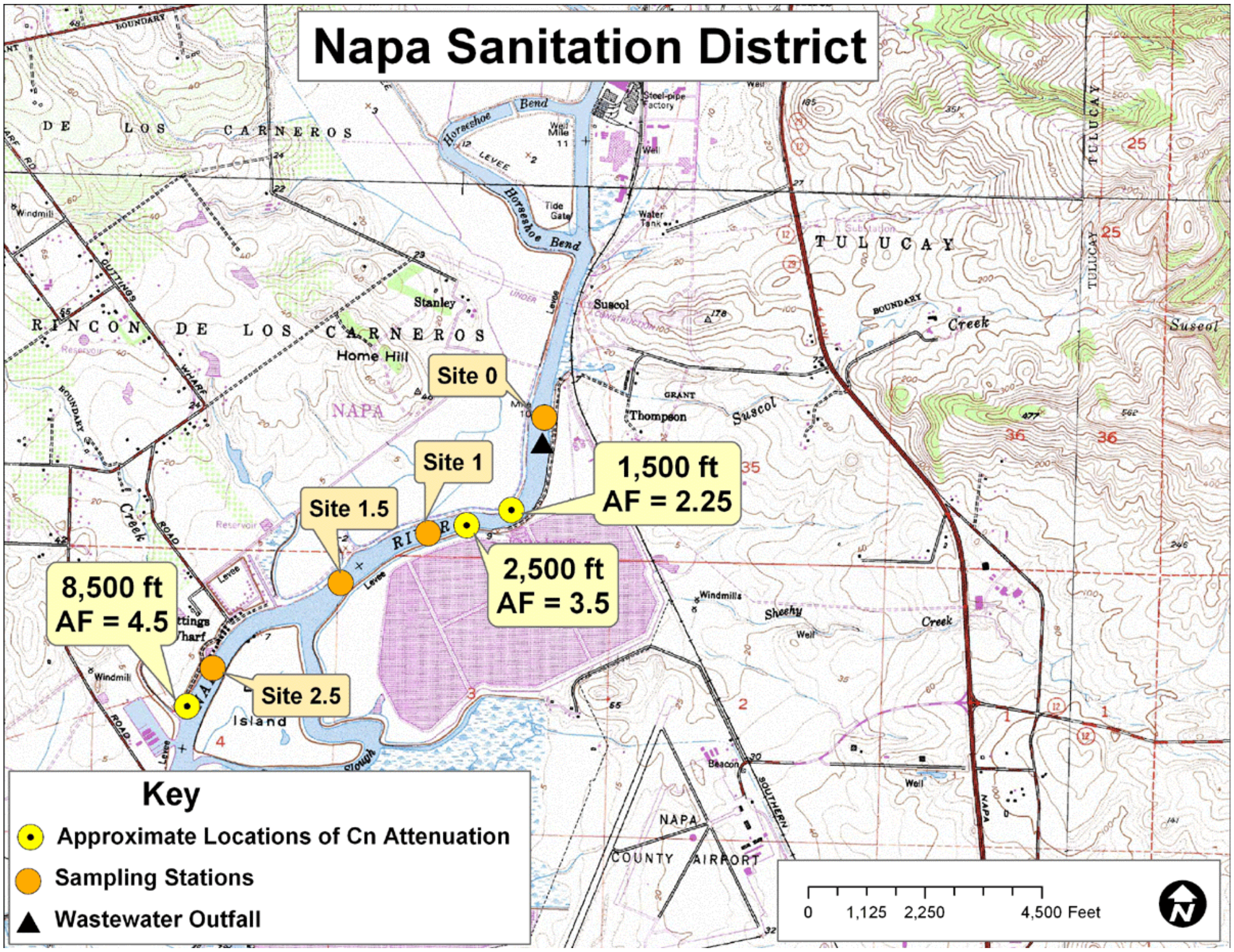
Mt. View Sanitary District
Empirical: Average Cyanide Concentration versus Distance from Effluent Outfall
Exponentially Extrapolated Over Distance (Best Fit Curve)



Napa Sanitation District

Site	Average Cyanide ug/l	No. data points	Distance from Outfall		Surface Water Area Between Sites		Median AF
			feet	kilometers	acres	sq. kilometer	
Napa Sanitation District							
Site 0	0.8	3	-20	0	0	0.00	-
Outfall	2.1	3	0	0	0	0.00	1
Attenuation	-	-	1,500	0.5	17	0.07	**2.25**
Attenuation	-	-	2,500	0.8	29	0.11	**3.5**
Site 1	0.6	3	3,279	1.0	37	0.15	4.0
Site 1.5	0.66	3	4,918	1.5	56	0.22	3.0
Site 2.5	0.6	3	8,197	2.5	94	0.37	4.0
Attenuation	-	-	8,500	2.6	95	0.38	**4.5**

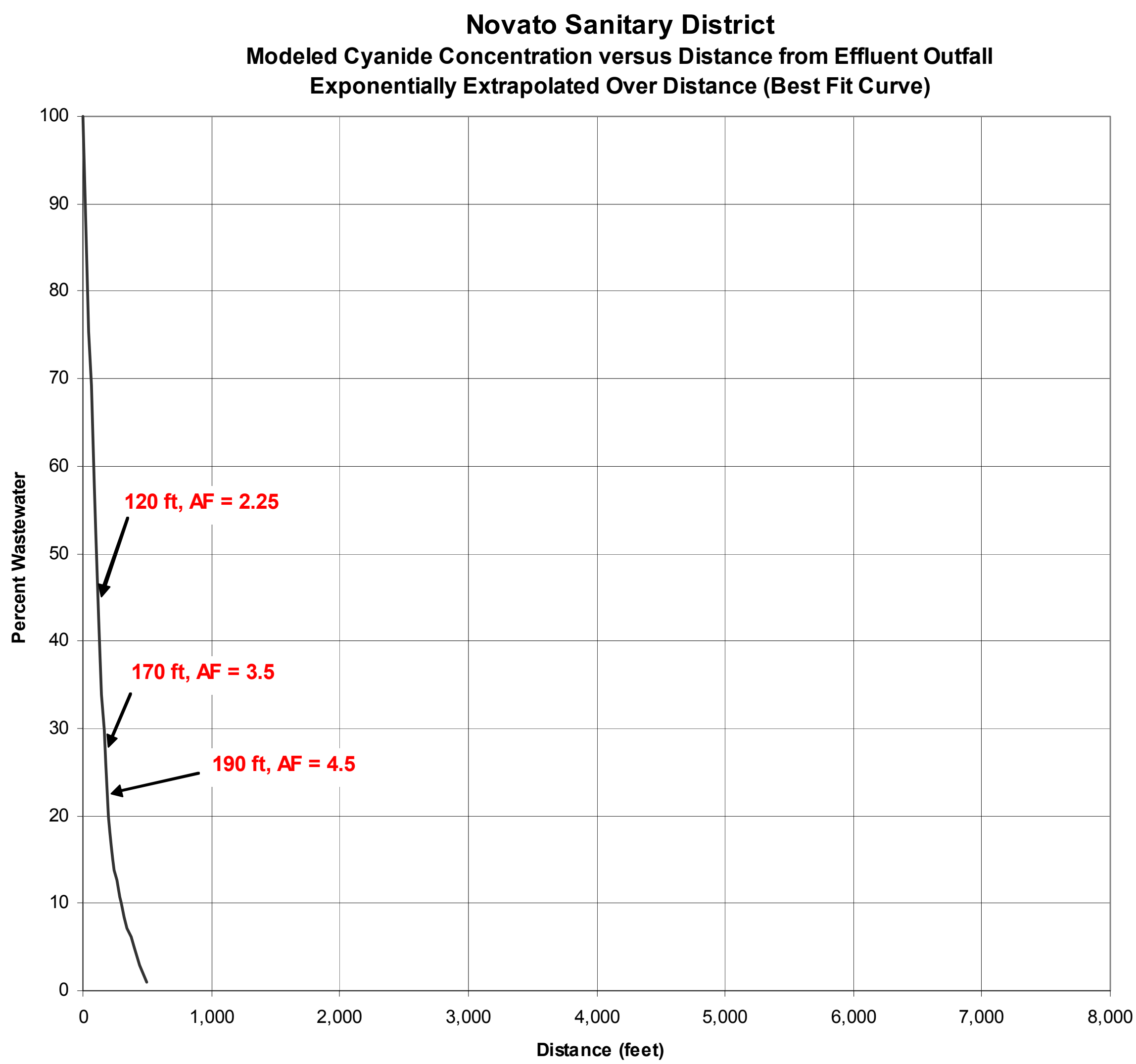


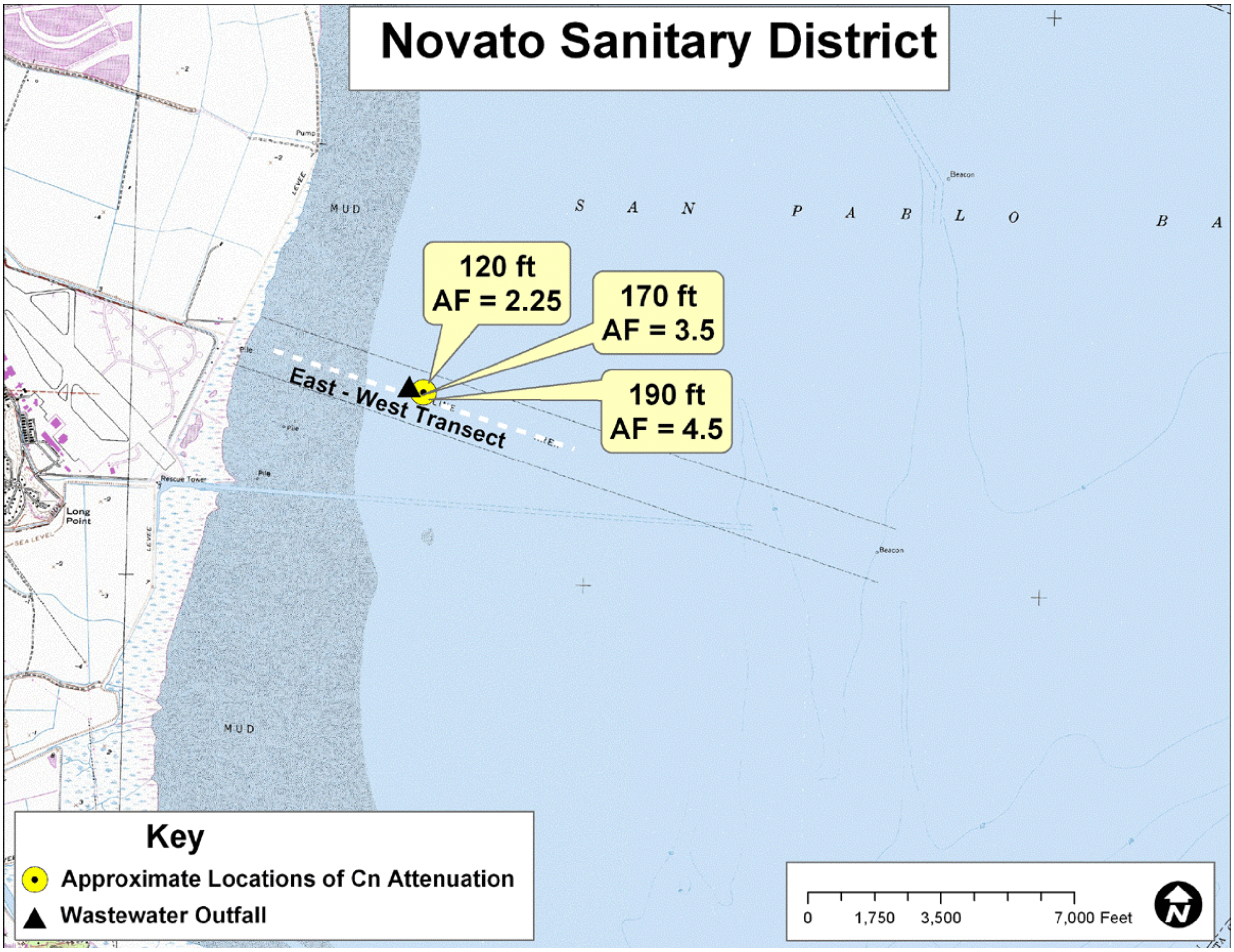

Napa Sanitation District
Site 0
Site 1
Site 1.5
Site 2.5
1,500 ft
AF = 2.25
2,500 ft
AF = 3.5
8,500 ft
AF = 4.5
Key
Approximate Locations of Cn Attenuation
Sampling Stations
Wastewater Outfall
0
1,125
2,250
4,500 Feet
N

Novato Sanitary District

Site	Cyanide ug/l	No. data points	Distance from Outfall		Surface Water Area Between Sites		AF†
			feet	kilometers	acres	sq. kilometer	
Novato Sanitary District							
Outfall	NA	-	0	0	0.00	0.0000	-
Attenuation	-	-	120	0.0	0.14	0.0006	**2.25**
Attenuation	-	-	170	0.1	0.19	0.0008	**3.5**
Attenuation	-	-	190	0.1	0.25	0.0010	**4.5**

† Attenuation Factors in bold were derived from modeled percent wastewater.



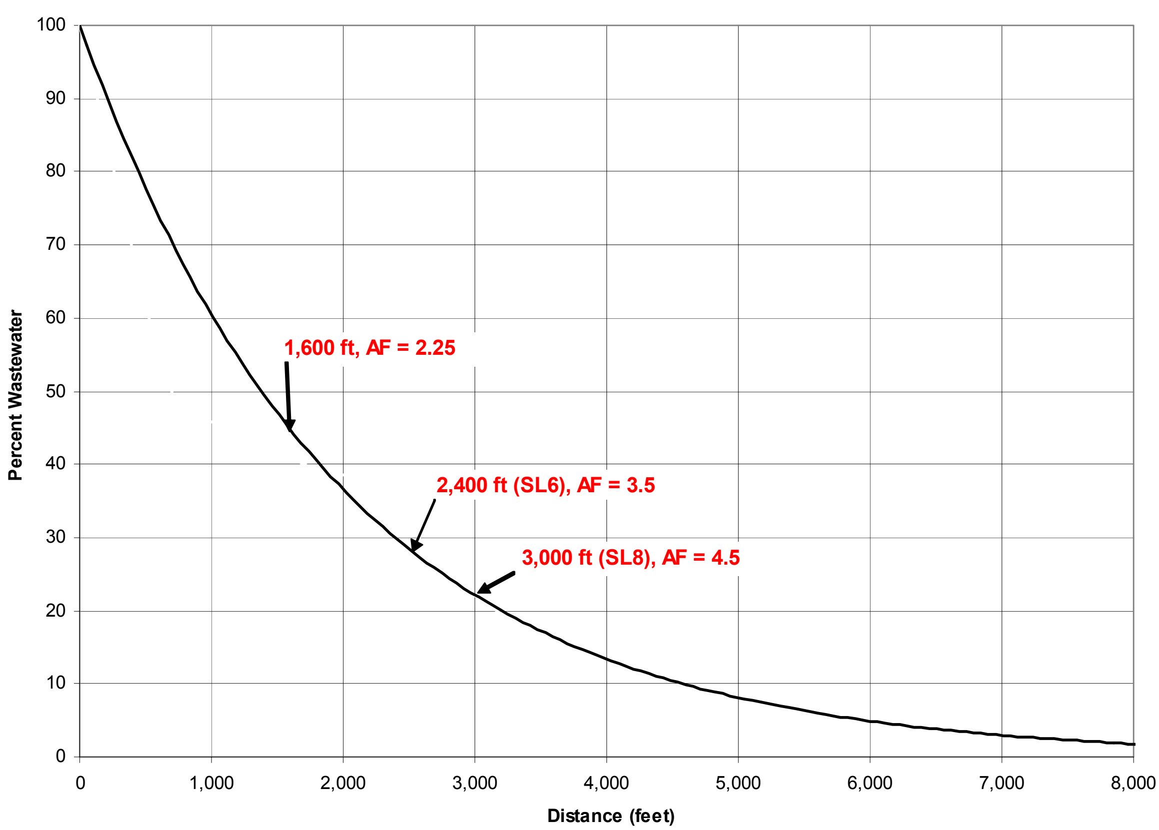

Novato Sanitary District
SAN PABLO BAY
MUD
120 ft
AF = 2.25
170 ft
AF = 3.5
190 ft
AF = 4.5
East - West Transect
Long Point
MUD
Key
Approximate Locations of Cn Attenuation
Wastewater Outfall
0
1,750
3,500
7,000 Feet

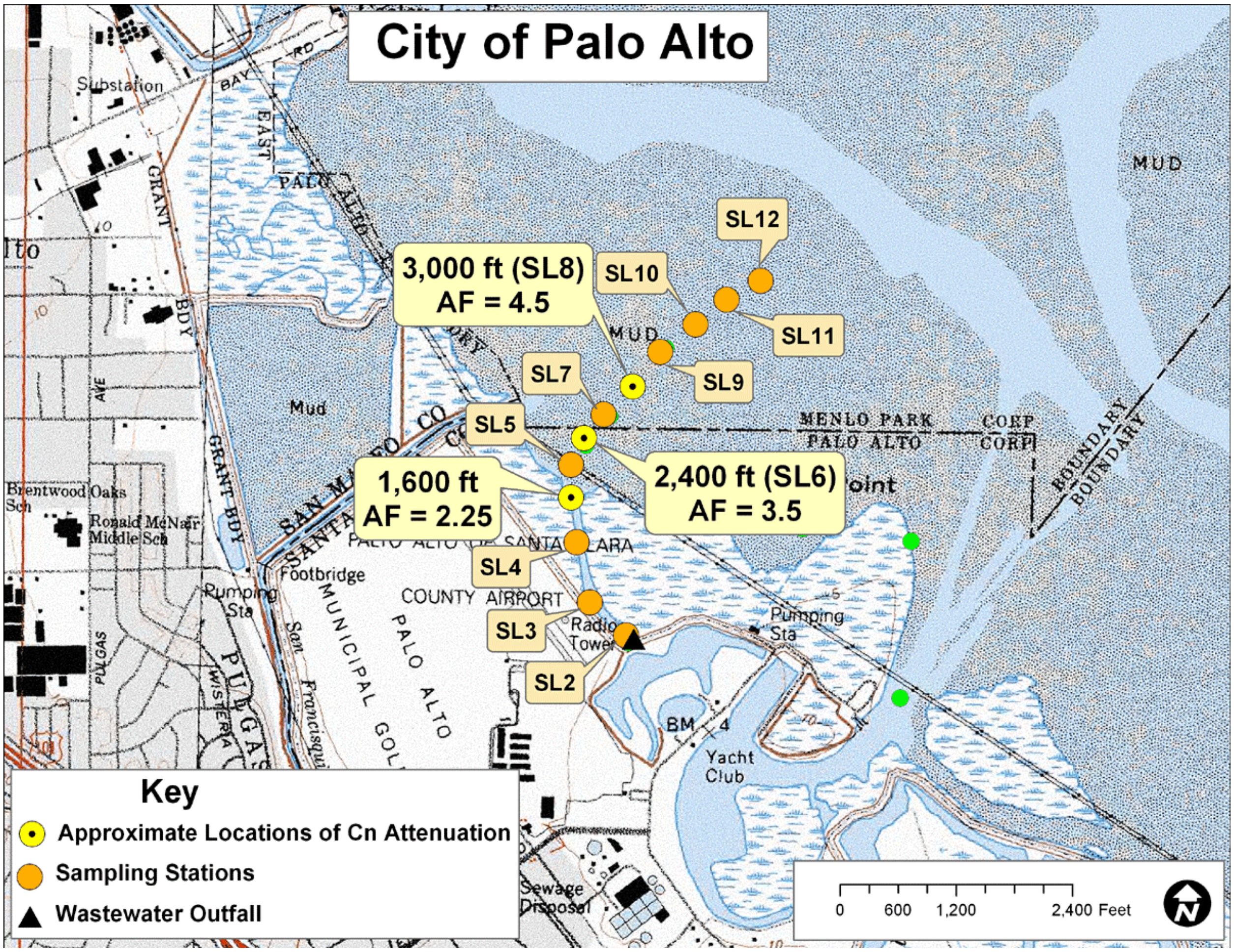
City of Palo Alto

Site	Cyanide ug/l	No. data points	Distance from Outfall		Surface Water Area Between Sites		AF†
			feet	kilometers	acres	sq. kilometer	
Palo Alto							
Outfall	4.5	9	0	0	0	0.000	1
SL2	1.5	1	20	0.0	0	0.000	1.6
SL3	4.87	9	500	0.2	1	0.004	1.1
SL4	3.55	4	1,200	0.4	2	0.009	1.1
Attenuation	-	-	1,600	0.5	4.2	0.017	**2.25**
SL5	0.54	9	2,000	0.6	5.0	0.020	11
Attenuation (SL6)	0.42	4	2,400	0.7	7	0.028	**3.5** (11.5)
SL7	0.1	1	2,650	0.8	14	0.055	24
Attenuation (SL8)	0.3	1	3,000	0.9	32	0.017	**4.5** (8)
SL9	0.4	1	3,520	1.1	80	0.020	6.0
SL10	0.6	1	4,000	1.2	400	0.028	4.0
SL11	0.9	1	4,500	1.4	900	0.055	2.7
SL12	0.6	1	5,000	1.5	2,500	0.126	4.0

† Attenuation Factors in bold were derived from modeled percent wastewater, AF numbers not in bold are the median AF derived using empirical data.

Palo Alto
Modeled Percent Wastewater versus Distance from Effluent Outfall
Exponentially Extrapolated Over Distance (Best Fit Curve)

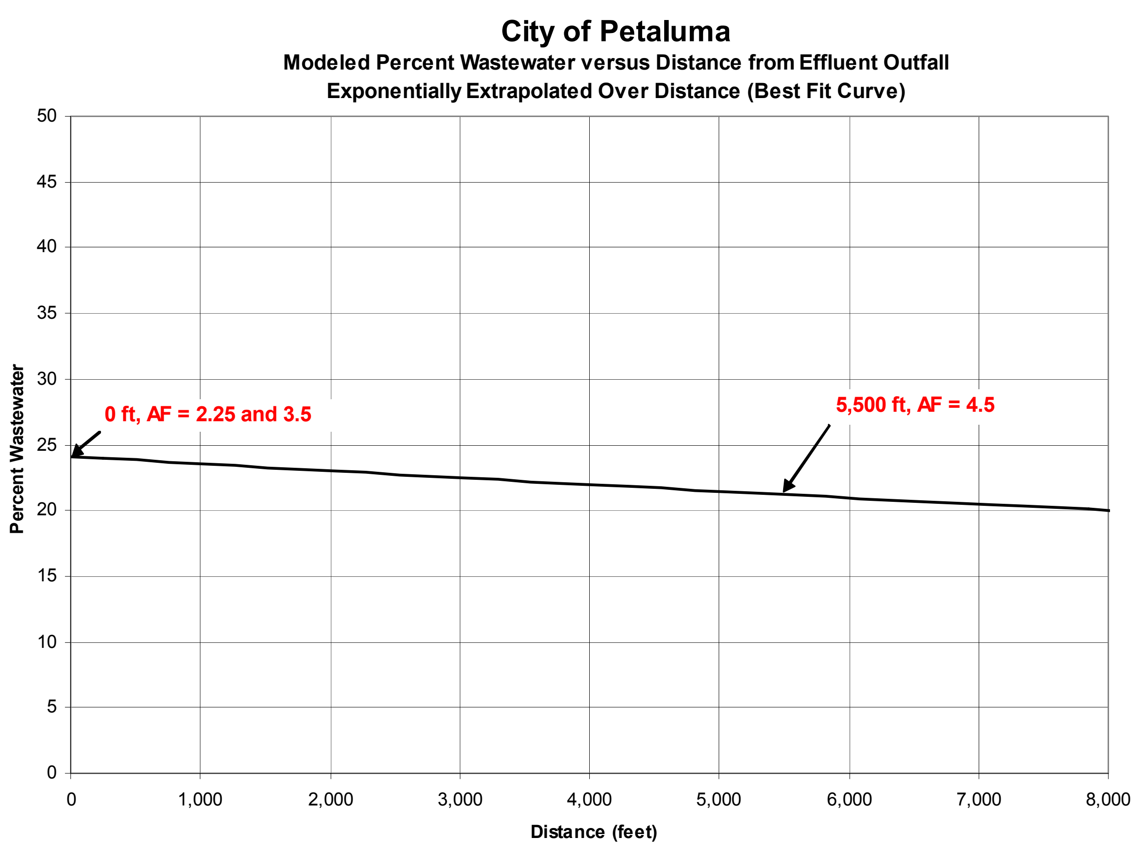


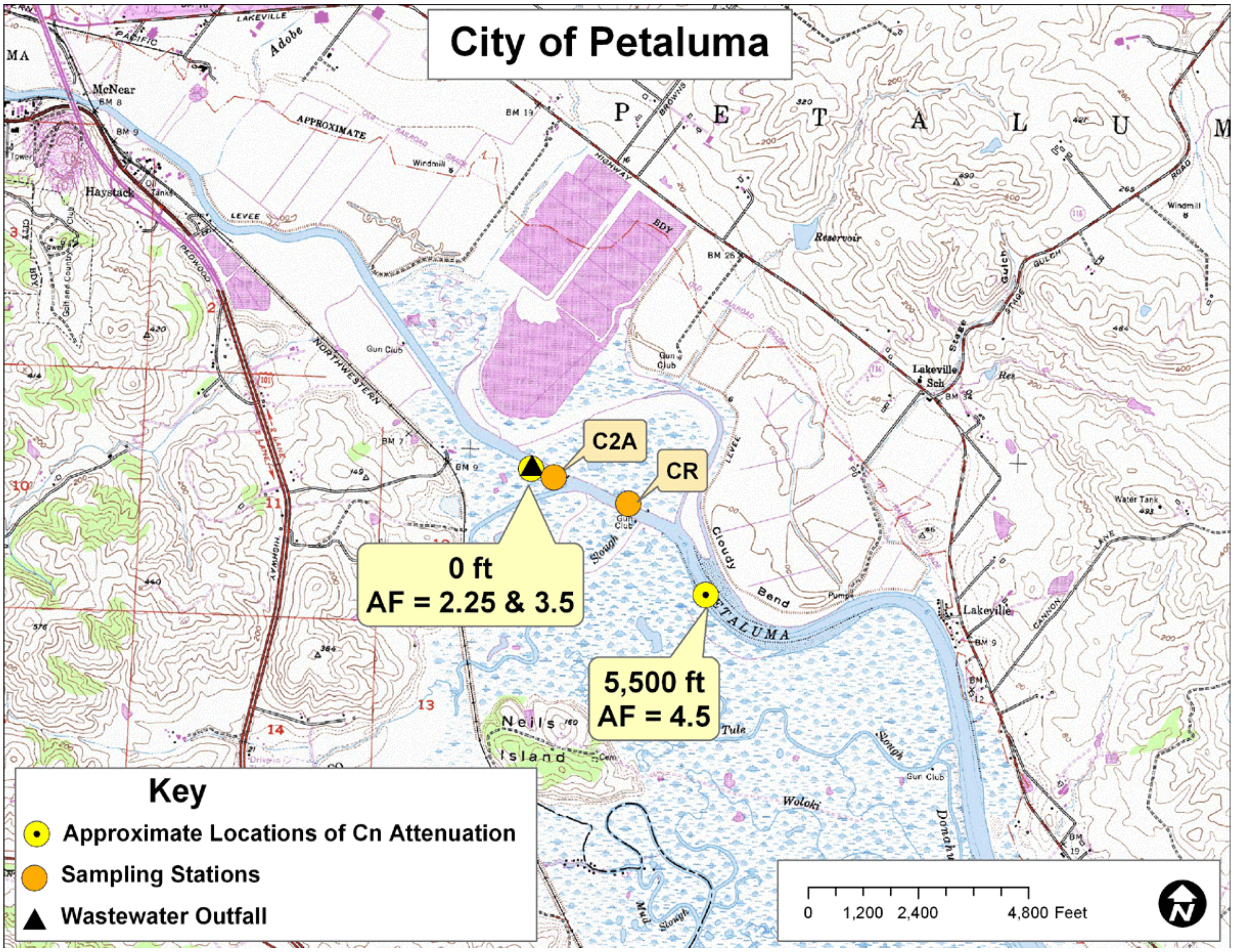

City of Palo Alto
SL12
3,000 ft (SL8)
AF = 4.5
SL10
SL11
SL9
SL7
SL5
2,400 ft (SL6)
AF = 3.5
1,600 ft
AF = 2.25
SL4
SL3
SL2
MENLO PARK
PALO ALTO
CORP
CORP
BOUNDARY
BOUNDARY
MUD
Mud
COUNTY AIRPORT
PALO ALTO
MUNICIPAL
Yacht Club
Sewage Disposal
Pumping Sta
Footbridge
Substation
Brentwood Oaks Sch
Ronald McNair Middle Sch
Key
Approximate Locations of Cn Attenuation
Sampling Stations
Wastewater Outfall
0
600
1,200
2,400 Feet

City of Petaluma

Site	Average Cyanide ug/l	No. data points	Distance from Outfall		Surface Water Area Between Sites		AF†
			feet	kilometers	acres	sq. kilometer	
City of Petaluma							
Outfall	1.067	3	0	0	0	0.000	1
Attenuation	-	-	0	0	0	0.000	**2.25**
Attenuation	-	-	0	0	0.0	0.000	**3.5**
C2A	0.73	3	500	0.2	2.3	0.009	1.25
CR	0.73	3	2,000	9.2	5.7	0.023	1.25
Attenuation	-	-	5,500	22.0	6.0	0.024	**4.5**

† Attenuation Factors in bold were derived from modeled percent wastewater, AF numbers not in bold are the median AF derived using empirical data.

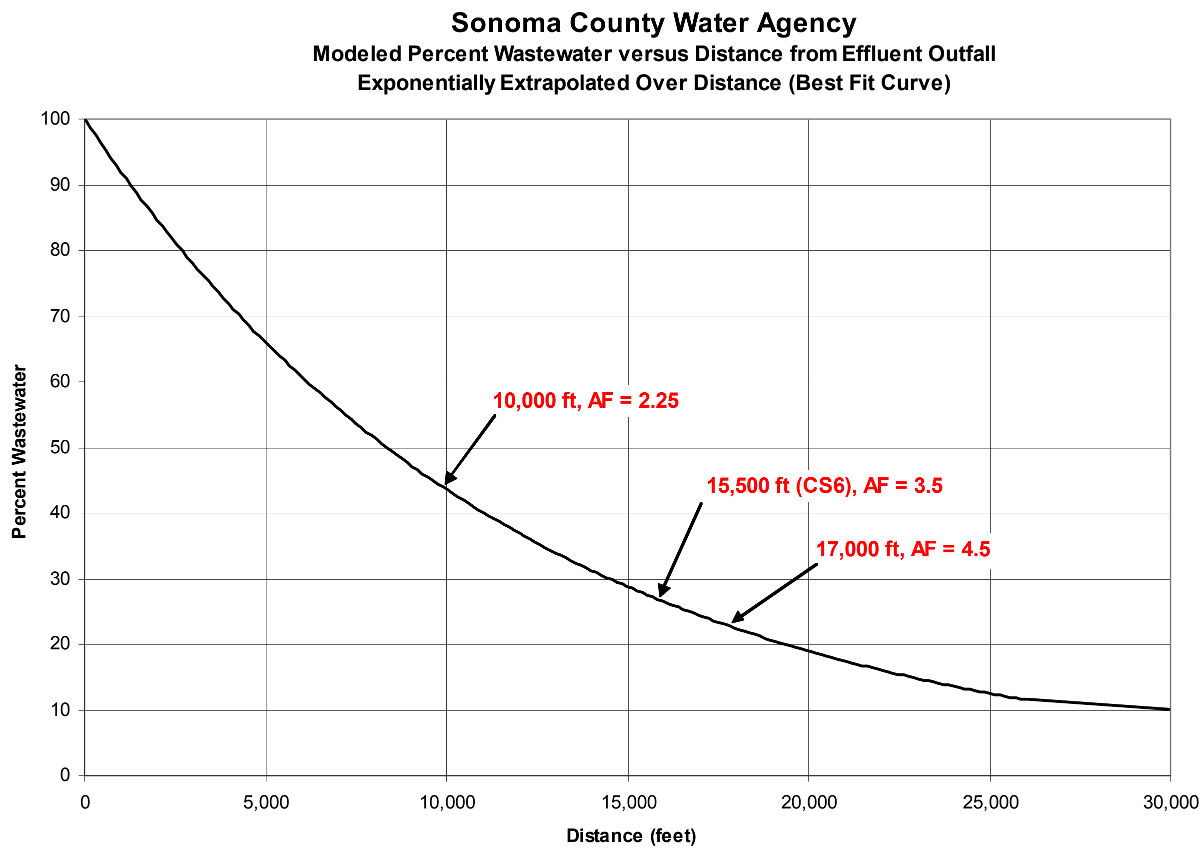


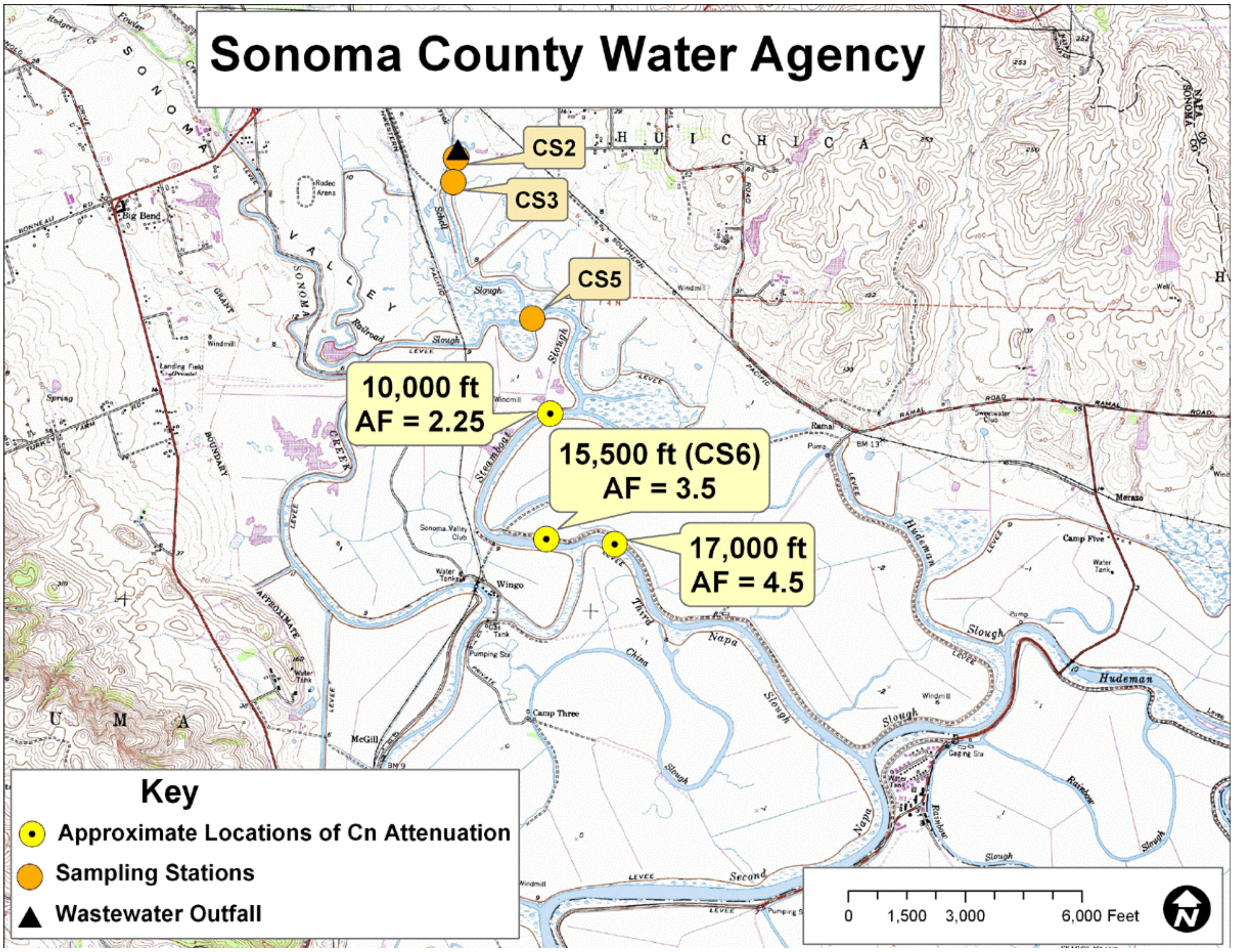

City of Petaluma
C2A
CR
0 ft
AF = 2.25 & 3.5
5,500 ft
AF = 4.5
Key
Approximate Locations of Cn Attenuation
Sampling Stations
Wastewater Outfall
0 1,200 2,400 4,800 Feet

Sonoma County Water Agency

Site	Average Cyanide ug/l	No. data points	Distance from Outfall		Surface Water Area Between Sites		AF†
			feet	kilometers	acres	sq. kilometer	
Sonoma County Water Agency							
Outfall	2.9	1	0	0	0	0.000	1
CS2	2.9	1	20	0.0	0	0.000	1
CS3	1.1	1	500	0.2	0.2	0.001	2.5
CS5	0.65	2	5,600	1.7	7.7	0.030	4.3
Attenuation	-	-	10,000	3.0	29	0.115	**2.25**
CS6	0.6	2	15,500	4.7	55	0.217	**3.5**
Attenuation	-	-	17,000	5.2	62	0.245	**4.5** (4.7)

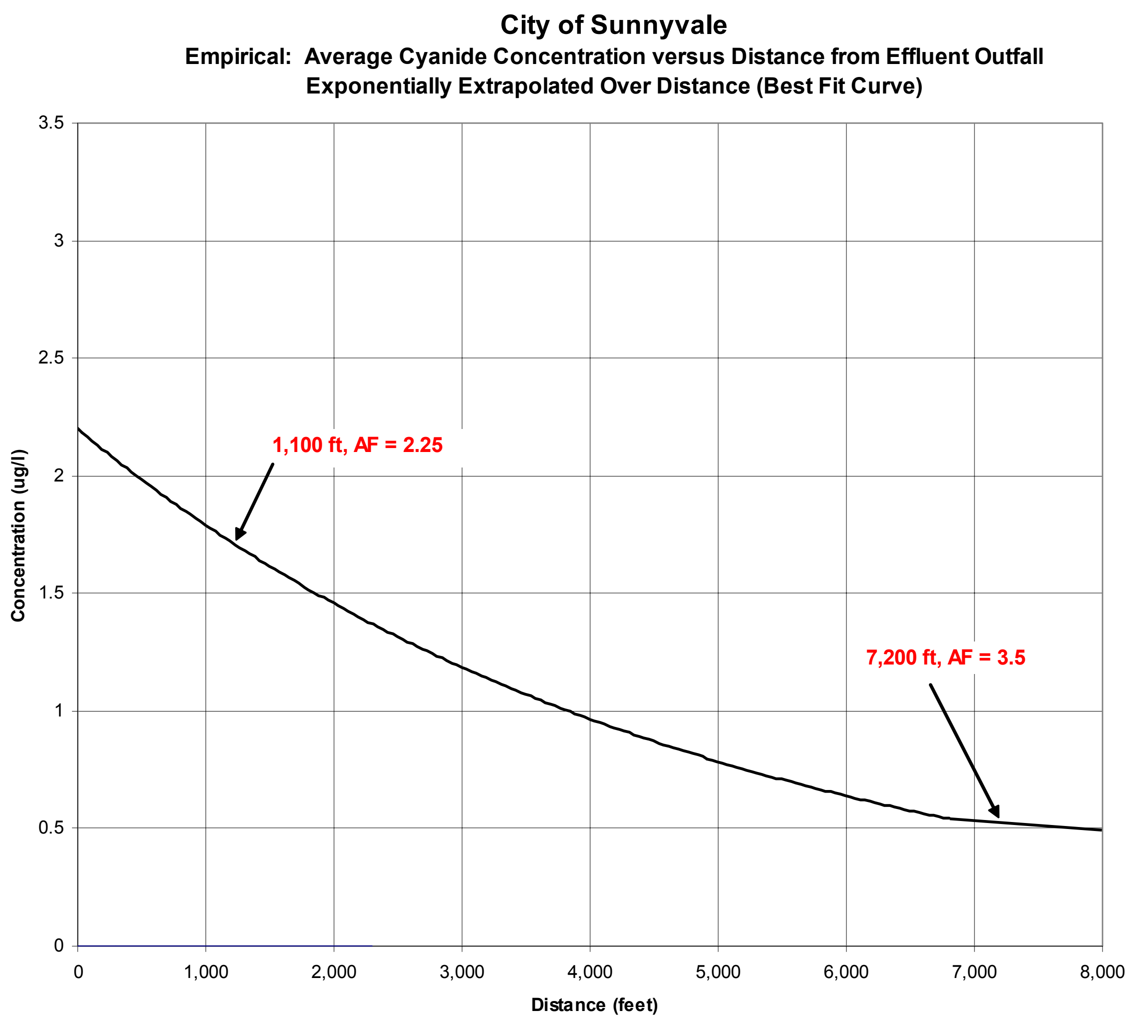
† Attenuation Factors in bold were derived from modeled percent wastewater, AF numbers not in bold are the median AF derived using empirical data.

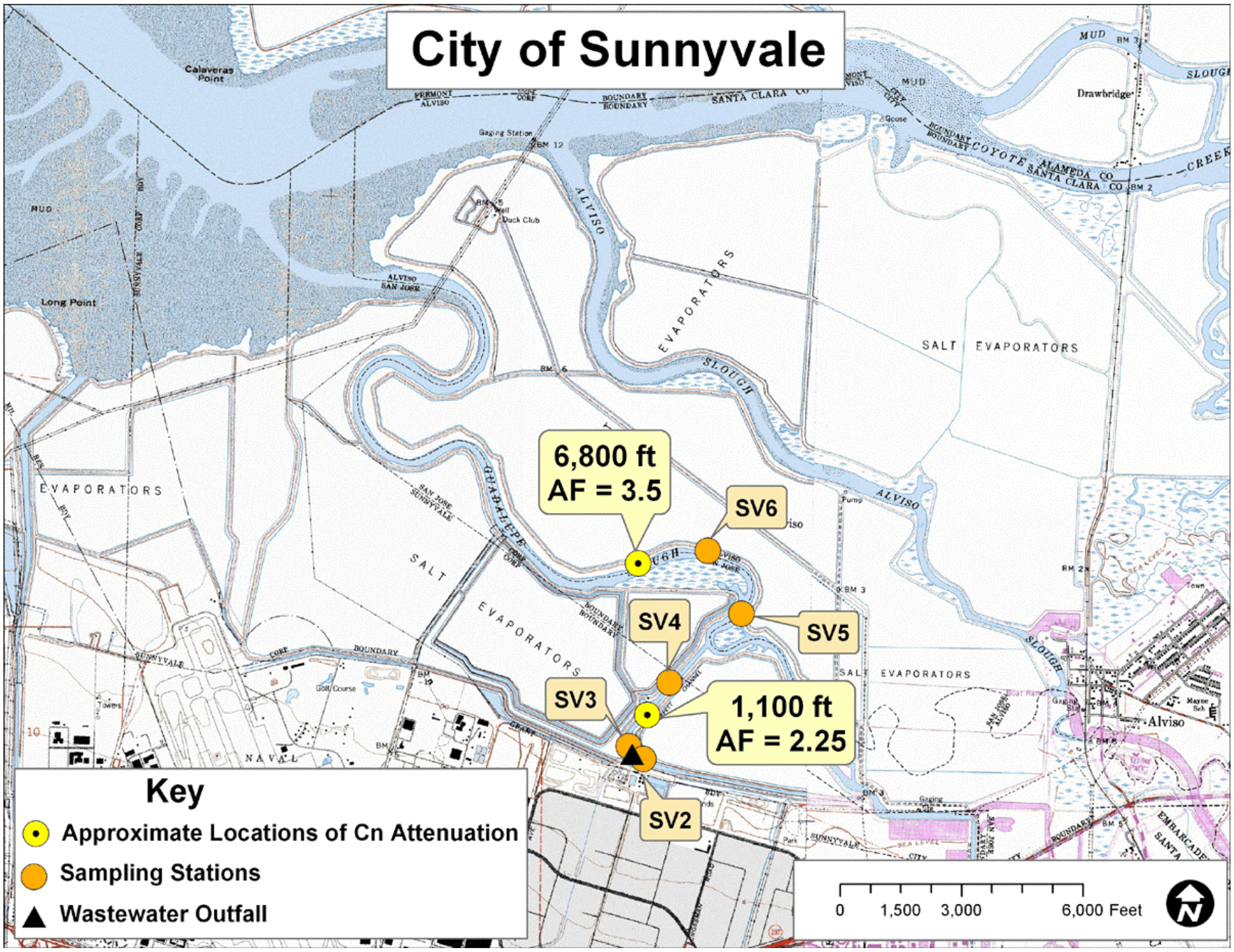



Sonoma County Water Agency
CS2
CS3
CS5
10,000 ft
AF = 2.25
15,500 ft (CS6)
AF = 3.5
17,000 ft
AF = 4.5
Key
Approximate Locations of Cn Attenuation
Sampling Stations
Wastewater Outfall
0 1,500 3,000 6,000 Feet

City of Sunnyvale

Site	Average Cyanide ug/l	No. data points	Distance from Outfall		Surface Water Area Between Sites		AF
			feet	kilometers	acres	sq. kilometer	
City of Sunnyvale							
SV2	2.2	1	-20	0	0	0.000	-
Outfall	2.2	1	0	0	0	0.000	1
SV-3	2.1	1	300	0.1	3	0.012	1
Attenuation	-	-	1,100	0.3	2	0.009	**2.25**
SV-4	0.7	1	2,300	0.7	5.8	0.023	3.1
SV-5	0.8	1	4,700	1.4	10.0	0.040	2.8
SV-6	0.7	1	6,800	2.1	11.5	0.045	3.1
Attenuation	-	-	7,200	2.2	13	0.049	**3.5**




City of Sunnyvale
6,800 ft
AF = 3.5
SV6
SV4
SV5
SV3
1,100 ft
AF = 2.25
SV2
Key
Approximate Locations of Cn Attenuation
Sampling Stations
Wastewater Outfall
0 1,500 3,000 6,000 Feet
SALT EVAPORATORS
ALVISO SLOUGH
GUADALUPE SLOUGH
Alviso

Area Measurement Methodology and Notes

Method for Surface Water Area Calculations

Surface water areas were calculated in GIS using ESRI ArcMap 8 software and USGS hydrologic GIS data (National Hydrologic Dataset, 1999). The NHD provides line map features (rivers and stream) and polygon map features (bays, lakes, estuaries, ponds). The extent of waterbodies (including estuarine) provided by the NHD are based on the USGS 7.5 minute topographic maps. According to the USGS Topographic Mapping Standards for mapping the extent of waterbodies, strict rules apply. In the case of estuarine creeks, the shoreline is defined where 'the water is at the stage that prevails when the feature is at or near capacity'. Using the NHD data, surface water areas were mapped for selected Shallow Water Dischargers along with their respective monitoring location. The respective slough or creek polygon feature was divided into sub-sections. The dividing lines for splitting the polygon feature were the monitoring locations. Once the slough or creek polygon feature was successfully sub-divided, area was calculated for each sub-section using the ‘calculate acres' script in ArcMap.

USGS Topographic Mapping Standards for Hydrography: *http://rockyweb.cr.usgs.gov*

Stream:

The limit of a STREAM/RIVER is the position of the shoreline when the water is at the stage that prevails when the feature is at or near capacity.

Appendix E

Summary of Water Quality Modeling Studies

Background

A number of shallow water dischargers have performed mathematical modeling studies of their discharges to waters of San Francisco Bay. The purpose of these studies has been to evaluate the water quality impact of individual discharges near the point of discharge and at locations in the Bay proper. Most of these modeling studies have used results from dye studies to check the results produced by the models. Dye studies provide empirical measures of plume movement over short time periods during and after the release of dye from a given outfall.

The dischargers that have performed mathematical water quality modeling studies are as follows:

- Novato SD (2004) (RMA, 2004)
- Fairfield Suisun SD (2004) (Flow Science, 2004)
- City of Petaluma (2001) (RMA, 2001)
- Sonoma County Water Agency (1997) (RMA, 1997)
- City of Palo Alto (1997) (RMA, 1997)
- City of San Jose (1989) (CH2M Hill, 1989)

Many of these studies have been prepared as part of a request to the San Francisco Regional Water Quality Control Board (Water Board) to grant a dilution credit in accordance with provisions in the San Francisco Bay Basin Plan (Basin Plan). Dating to the 1986 Basin Plan, provisions have existed for individual shallow water dischargers to request dilution credit (SFBRWQCB, 1995). These requests have included the need to demonstrate compliance with water quality objectives in near-field receiving waters.

For cyanide, the results of modeling studies performed to date are useful in the prediction of cyanide levels in the vicinity of shallow water discharges. Predictions can be made based on presumed percentages of effluent at different distances from the point of discharge.

Mathematical Modeling Methodology

The mathematical modeling that has been performed is in all cases based on the results from two linked models: (1) a hydrodynamic model that predicts the mixing of effluent in the estuarine waters of the Bay or its tributaries and (2) a water quality model that predicts the water quality conditions that will occur at various locations in the Bay due to the tidal mixing, advection and turbulent diffusion of treated wastewater effluent in the Bay. Typically, the flow, current, and stage information derived through the hydrodynamic model is used as input to the water quality model.

Descriptions of the modeling methodologies used to date are provided in the modeling reports described below.

Modeling Results

Modeling results from three dischargers are used to demonstrate the dilution characteristics in the vicinity of three different types of shallow water discharges. Those types are (1) discharge to the shallow mudflats along the periphery of the Bay (Novato Sanitary District); (2) discharge to a small dead-end channel along the periphery of the Bay (City of Palo Alto); and (3) discharge to a channelized slough remote from the Bay (Fairfield-Suisun Sewer District).

Novato Sanitary District

The Novato discharge has been modeled on two occasions by RMA, Inc. of Suisun, California. The first occasion was in 1997 as part of an application for dilution credit to the Water Board. A more recent (2004) modeling effort was performed as part of the anti-degradation analysis that the District is conducting as part of a request to increase the permitted discharge from 6.55 mgd to 7.0 mgd ADWF (RMA, 2004). Results from the modeling work will also be used in the assessment of water quality impacts of the proposed expansion project as part of an environmental impact report under CEQA.

The Novato discharge is located in the mudflat area along the western periphery of San Pablo Bay. The outfall is a pipeline that terminates approximately 300 feet from the shore. Most of the time, the discharge is submerged in the shallows of the mudflat. At low tides, for short time intervals, the outfall is exposed and effluent runs along a rivulet in the mudflat toward the deeper channel of the Bay. Flood tides over the mudflat results in significant mixing of the effluent with Bay waters.

The RMA models used to assess the water quality impacts of the Novato discharge are described in a March 2004 report for the District. In brief, the models used are finite element hydrodynamic and water quality models.

The models used in the analysis are RMA-2 and RMA-11. RMA-2 is a generalized free surface hydrodynamic model that is used to compute a continuous temporal and spatial description of fluid velocities and water depth throughout the San Francisco Bay and estuary. RMA-11 is a generalized two-dimensional water quality model that computes temporal and spatial descriptions of water quality parameters (both conservative and non-conservative) parameters. RMA-11 uses the results from RMA-2 for its description of the flow field.

The models have been calibrated against observed data in the Bay. The hydrodynamic model was calibrated against observed current velocities and stage data for San Pablo Bay generated in 1979 and 1980. The water quality model was calibrated for the same period using USGS salinity data. The water quality model was also calibrated against dye study results performed in March 1978 by E.H. Smith and Associates. Finally, predicted dissolved copper and dissolved nickel results were checked against actual RMP data at various RMP stations to further refine the modeling results.

The models are constructed in sufficient detail to represent the bathymetry of the Bay near the Novato discharge point and in the body of the Bay based on NOAA charts and data. The finite element network includes the entire Bay and Sacramento-San Joaquin Delta so that tidal currents are computed based on the tide at the Golden Gate, bay inputs and tributary stream inflows. The models are capable of simulating sheet flow over mud flats and movement of water over the deeper sections of the Bay in response to tidal activity. The models compute current velocities, water depth and the concentration of water quality parameters at 7.5-minute time steps throughout the tidal cycle. The model output can then be used to calculate hourly, 24-hour and 4-day average values of dilution and water quality concentrations at any desired point in the Bay.

The modeling performed by RMA allows for the development of effluent concentration profiles along directions parallel and perpendicular to the Novato outfall. This provides a picture of the dilution field around the Novato discharge, which approximates, in two dimensions, the three dimensional plumes that exist around deep water discharges. This distinguishes the Novato discharge from most of the other shallow water discharged to the Bay; other shallow water discharges exhibit more linear (one dimensional) dilution gradients due to their location in sloughs and channels.

Results from the Novato modeling effort are shown graphically in the March 2004 RMA report. Those results, derived for critical dry Delta outflow conditions, indicate maximum hourly average percent effluent levels of 70 percent at the point of discharge, with maximum hourly effluent percentages dropping to 10 percent at distances of 250 feet in either direction from the discharge. For maximum daily average effluent levels, the model results show a maximum of 12 percent effluent above the point of discharge dropping to less than 3 percent within 250 feet of the discharge point. The curves generated for the Novato report can be used to develop predicted cyanide concentrations in the Bay at given effluent concentrations.

City of Palo Alto

The City of Palo Alto discharges advanced secondary effluent into a short, unnamed channel along the western side of South Bay. The Palo Alto discharge was modeled by RMA, Inc, as part of a request to the Water Board for consideration of providing a dilution credit to the City for NPDES permit purposes (RMA, 1997). The models used in the Palo Alto work (RMA-2 and RMA-11) are the same models used by RMA in the above-described work for Novato Sanitary District. The inputs to the model were adjusted to reflect near-field conditions and bathymetry existing near the City of Palo Alto's discharge point.

The model was calibrated against the field observations derived from a dye study performed for the City in 1990 by Woodward Clyde Consultants. Additionally, modeling results for dissolved copper were checked against observed ambient copper concentrations in South Bay to finalize proper adjustments to the model.

Instantaneous, 24-hour average and 4-day dilution contours during critical dry season conditions were developed by RMA for the City of Palo Alto using the above-described models. These contour plots are provided as color figures in the December 1997 modeling report to the City. The information in these contour plots can be used to directly estimate ambient cyanide concentrations along the Palo Alto discharge gradient based on given effluent cyanide concentrations.

Fairfield-Suisun Sewer District

Flow Science Inc. from Pasadena, CA modeled the Fairfield-Suisun Sewer District (FSSD) discharge in 2004. Flow Science employed the Fischer Delta Model to assess the affect of the FSSD discharge of advanced secondary effluent from the point of discharge in Boynton Slough into Suisun Slough and thence to Grizzly Bay (Flow Science, 2004). The Fischer Delta Model employs a hydrodynamic model (DELFLO) and a water quality model (DELSAL) in its analytical approach.

Dilution characteristics were modeled for two water year conditions: 1991 (representative of a critical [dry] year condition with low Delta outflows in the winter and spring) and 1998 (representative of a wet year condition with elevated Delta outflows for a portion of the winter/spring period. Given the location of the FSSD discharge point in the northern region of the FSSD discharge point in the northern region of the Bay in Suisun Marsh, it was hypothesized that dilution characteristics of the FSSD discharge may vary with Delta outflow condition. In fact, the water quality modeling showed that dilution characteristics of the FSSD discharge are insensitive to water year conditions and that the effects are highly localized in Boynton Slough and the connecting reach of Suisun Slough.

The following is the typical percentage of effluent located at various points along the discharge gradient from Boynton Slough and Suisun Slough toward Grizzly Bay:

Station C1: 100 percent effluent
Station C2: 95 percent effluent
Station C4: 79 percent effluent
Station C6: 77 percent effluent
Station C5: 47 percent effluent
Station SU42: 4 percent effluent

The model was used to generate probability plots of percentage occurrence at different locations. The above percentages are 95^{th} percentile occurrence values. A map of these stations is provided in the Flow Science modeling report.

The information derived from the modeling of effluent percentages at given locations allows the calculation of ambient concentrations of cyanide along the discharge gradient at a given value of effluent cyanide and background cyanide levels in Grizzly Bay.

Summary

The above information provides an indication of the usefulness of available dilution modeling results on the prediction of cyanide levels in ambient waters near other shallow water discharges. Available modeling information could be used to determine dilution (i.e. percentage effluent values) in the vicinity of shallow water discharges. This information could then be compared with observed cyanide levels along discharge gradients to validate the change in ambient cyanide concentrations due to dilution.

References

RMA 1997. *Dilution Analysis and Water Quality Impacts of the Palo Alto Regional Water Quality Control Plant on South San Francisco Bay.* Prepared for the City of Palo Alto. December 1997.

RMA 2001. *Water Quality Impacts of City of Petaluma Wastewater Treatment Plant Discharge in Petaluma River and San Pablo Bay.* Draft report prepared for City of Petaluma under subcontract to Larry Walker Associates. June 2001.

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Appendix F

Cyanide Attainability Analysis for Shallow Water Dischargers

CYANIDE ATTAINABILITY ANALYSIS FOR SHALLOW WATER DISCHARGERS

(Attenuation Factors = 2.25, 3.0, 3.5, and 4.5)

PURPOSE OF ANALYSIS

This document presents the statistical analysis results in the determination of compliance attainability with the water quality-based effluent limitations (WQBELs), specifically, the daily maximum effluent limitation (MDEL) and the monthly average effluent limitation (AMEL), calculated using four cyanide attenuation factors (AF), 2.25, 3.0, 3.5, and 4.5, for thirteen shallow water dischargers.

When calculating WQBELs using SIP procedures, an attenuation factor (AF) is applied the same way as a dilution factor (D), i.e., to replace the D in the equation with the AF.

The twelve shallow water dischargers for which cyanide marine water quality objectives are:

1. City of American Canyon
2. Fairfield Suisun Sewer District
3. Hayward Shore Marsh Effluent
4. Las Gallinas Valley Sanitary District
5. Mountain View Sanitary District
6. Napa Sanitation District
7. Novato Sanitary District
8. City of Palo Alto
9. City of Petaluma
10. San Jose/Santa Clara Valley Water Pollution Control Plant
11. Sonoma Valley County Sanitation District
12. City of Sunnyvale

STATISTICAL ANALYSIS PROCEDURES AND PRODUCTS

The statistical analyses performed include the following:

1. Estimate statistics from the cyanide effluent data collected during 2000-2003: Since many of the data sets are censored data sets, i.e., many measurements are below detection limits (non-detect), a probability regression method was used to estimate the mean, standard deviation, coefficient of variation, as well as the 95th and the 99th percentiles. For this analysis, lognormal distribution was used assuming that individual cyanide effluent data sets follow this distribution.

   Attachment 1 includes the probability plots of cyanide data (most of them are censored probability plots) from the 12 dischargers. From these probability plots, one can tell how well a theoretical distribution fits the effluent data, therefore, to predict the how good the statistical estimates are. For bad distribution fits, one can expect large deviations of the statistical estimates from the true population parameters.

2. Calculate AMELs and MDELs using different attenuation factors. **Attachments 2 through 5** show the detailed calculation results.

3. To determine compliance attainability statistically, we compare the mean, the 95^{th}, and the 99^{th} percentiles with the LTA (long term average), AMEL, and MDEL from the WQBEL calculation, respectively. If any of the statistical estimates (the mean, the 95^{th}, and 99^{th} percentiles) is greater than its corresponding criteria (the LTA, AMEL, and MDEL), then statistically it indicates there might be compliance problem. The summary of this analysis results for all four attenuation factors is found in Table 16.

4. To visualize the actual compliance or exceedance of the effluent data with the MDEL or AMEL, time series plots of all available cyanide effluent data during 2000-2005 were generated, with the MDEL or AMEL plotted as horizontal on the same plot. If the effluent data points fall above any of the two lines, it indicates an exceedance. **Attachment 7** gives these time series plots with the MDEL and AMEL lines, for all four attenuation factors.

RESULTS

The following gives a brief summary of the statistical determination of compliance attainability and the comparison results of actual effluent measurements with AMELs and MDELs.

1. City of American Canyon:

AF=2.25: Attainability = Yes.
AF=3.0: Attainability = Yes.
AF=3.5: Attainability = Yes.
AF=4.5: Attainability = Yes.

There is one effluent measurement exceeding the AMEL at AF=2.25. There is no other exceedance of either the AMELs or MDELs.

2. Fairfield Suisun:

AF=2.25: Attainability = No (Mean>LTA, 95^{th}>AMEL, 99^{th}>MDEL).
AF=3.0: Attainability = No (95^{th}>AMEL, 99^{th}>MDEL).
AF=3.5: Attainability = No (95^{th}>AMEL).
AF=4.5: Attainability = No (95^{th}>AMEL).

At AF=4.5, there is one cyanide effluent measurement exceeding the MDEL, and three exceeding the AMEL. There are two exceedances of the MDELs and many exceedances of the AMELs at other three attenuation factors, indicating potential compliance problem. However, since the Discharger sampled twice per month most of the time during 2000-2004, by comparing the monthly averages with the AMELs, the number of exceedances drops significantly for attenuation factors 2.25, 3.0, and 3.5: There are only two exceedances of the AMELs at AF=3.0, 3.5, and 4.5, both exceedances are caused by two high measurements, 23 and 28 μg/L, which are above the theoretical LC0 for rainbow trout of 22 μg/L.

3. Hayward Marsh Effluent

AF=2.25: Attainability = No (Mean>LTA).
AF=3.0: Attainability = Yes.
AF=3.5: Attainability = Yes.
AF=4.5: Attainability = Yes.

There is/are one or two measurement(s) exceeding the AMELs for all four attenuation factors. There is no exceedance of the MDELs. However, the distribution fit is not good enough, and the percentile estimates of the mean and percentiles are most likely inflated (overestimate).

4. Las Gallinas (LGVSD)

AF=2.25: Attainability = No (95^{th}>AMEL).
AF=3.0: Attainability = Yes.
AF=3.5: Attainability = Yes.
AF=4.5: Attainability = Yes.

There is only one measurement exceeding the AMELs at AF=2.25, 3.0, and 3.5.

5. Mountain View SD

AF=2.25: Attainability = Yes.
AF=3.0: Attainability = Yes.
AF=3.5: Attainability = Yes.
AF=4.5: Attainability = Yes.

The cyanide data set is too limited, therefore, it is not recommended to estimate statistics using the parametric method. Time series plots show no exceedance of the AMELs or MDELs for any of the four attenuation factors, indicating no compliance issue.

6. Napa SD

AF=2.25: Attainability = No (95^{th}>AMEL).
AF=3.0: Attainability = No (95^{th}>AMEL).
AF=3.5: Attainability = Yes.
AF=4.5: Attainability = Yes.

These is one exceedance of the AMEL at AF=2.25. There is no exceedance of the AMELs at the any of the other three attenuation factors. There are two to six exceedances of the MDELs calculated using the four attenuation factors.

7. Novato

AF=2.25: Attainability = Yes.
AF=3.0: Attainability = Yes.
AF=3.5: Attainability = Yes.
AF=4.5: Attainability = Yes.

There is no exceedance of any of the AMELs or MDELs.

8. City of Palo Alto

AF=2.25: Attainability = Yes.
AF=3.0: Attainability = Yes.
AF=3.5: Attainability = Yes.
AF=4.5: Attainability = Yes.

There is no exceedance of any of the AMELs or MDELs.

9. Petaluma

AF=2.25: Attainability = No (95^{th}>AMEL, 99^{th}>MDEL).
AF=3.0: Attainability = No (95^{th}>AMEL).
AF=3.5: Attainability = No (95^{th}>AMEL).
AF=4.5: Attainability = Yes.

There are/is 4, 1, 1 exceedance(s) of the AMELs at AF=2.25, 3.0, and 3.5, respectively. There is no exceedance of the AMEL at AF=4.5 or any of the MDELs.

10. San Jose/Santa Clara

AF=2.25: Attainability = Yes.
AF=3.0: Attainability = Yes.
AF=3.5: Attainability = Yes.
AF=4.5: Attainability = Yes.

There is no exceedance of any of the AMELs or MDELs.

11. Sonoma Valley County SD

AF=2.25: Attainability = No (95^{th}>AMEL).

AF=3.0: Attainability = No (95^{th}>AMEL).
AF=3.5: Attainability = Yes.
AF=4.5: Attainability = Yes.

There are/is 5, 3, 2, and 1 exceedance(s) of the AMELs at AF=2.25, 3.0, 3.5, and 4.5, respectively. There is no exceedance of any of the MDELs.

12. City of Sunnyvale

AF=2.25: Attainability = No (Mean>LTA, 95^{th}>AMEL, 99^{th}>MDEL).
AF=3.0: Attainability = No (Mean>LTA, 95^{th}>AMEL, 99^{th}>MDEL).
AF=3.5: Attainability = No (95^{th}>AMEL).
AF=4.5: Attainability = No (95^{th}>AMEL).

There is only one exceedance of the MDEL at all attenuation factors, however, there are significant numbers of exceedances of the AMELs at all attenuation factors. For example, there are five measurements above the AMEL at AF=4.5. This indicates that the Discharger will have compliance issues based on the available effluent performance data. Since the higher values from this dataset may be environmentally significant in a shallow water discharge environment where stratification of effluent occurs (i.e., effluent cyanide concentration significantly greater than the marine final acute value (FAV) or freshwater CMC for rainbow trout), the finding that this Discharger may have attainability issues does not appear to be justification for a higher attenuation factor, especially in light of other discharger performance data.

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Compliance Attainability Summary

For an attenuation factor of **2.25**, only **five** dischargers will be able to achieve compliance: City of American Canyon, Mountain View, Novato, Palo Alto, and San Jose/Santa Clara.

For an attenuation factor of **3.0**, in addition to the above five dischargers, two more dischargers (a total of **seven**) will be able to achieve compliance: Hayward Marsh Effluent and Las Gallinas Valley Sanitation District.

For an attenuation factor of **3.5**, only three dischargers will have compliance issues (the other **ten** will be able to achieve compliance), which are Fairfield Suisun, City of Petaluma, and City of Sunnyvale. However, the time series plots for Petaluma cyanide effluent concentrations do not seem to indicate a compliance problem.

For an attenuation factor of **4.5**, Fairfield Suisun and Sunnyvale are the only two dischargers that will have some compliance issues; the other **eleven** will be able to achieve compliance.

More Frequent Sampling than Once Per Month Recommended

When determining compliance attainability using the statistical three-point comparison, i.e., mean versus LTA, 95^{th} percentile versus AMEL, and 99^{th} percentile versus MDEL, it seems that the 95^{th}/AMEL is the trigger indicating compliance infeasibility for most cases. Since most dischargers sample only once every month, it is practically comparing a daily sample with a monthly average limit. The time series plots also show that most exceedances are against the AMELs, unless for a few very high effluent concentrations. If the dischargers will sample more than once per month, the chance of exceeding an AMEL drops significantly: This has been illustrated by the Fairfield case. Therefore, the dischargers are encouraged to sample more than once per month to level off any high daily concentrations when comparing with the AMEL.

Recommended Attenuation Factor

Selection of a recommended cyanide attenuation factor was an iterative process, considering protection of water quality and attainability of probable future effluent limits. As discussed in Sections 7.3 and 9.2.1 of the staff report, the San Jose gradient study of cyanide attenuation suggested that where the average attenuation (based on 11 months of monthly data) was between 2.25 and 4.5, the proposed site-specific water quality objective was always attained. Based on this empirical evidence, these two values were chosen as the upper and lower boundaries of potential attenuation credit to allow shallow water dischargers in calculation of effluent limitations. AF's were evaluated iteratively to arrive at a recommended value for implementation in required effluent limitations.

It is quite clear that at AF=2.25, many dischargers will have compliance issues, even with more frequent sampling.

At AF=3.0, Sunnyvale may have bigger compliance issues than the others. If Sunnyvale samples more frequently, it might be able to improve percent of months in compliance, but may still have difficulty in achieving compliance. Fairfield may be able to achieve compliance.

If we choose AF=3.5, with more frequent sampling, Sunnyvale may be able to achieve compliance. Fairfield should be able to achieve compliance, except for the two spiked concentrations, which might be caused by dumping events, and probably should not be viewed as in compliance with environmentally protective thresholds.

The dischargers that would have challenges meeting 3.5 are the same as 4.5, so an AF of 3.5 is recommended as the most conservative attenuation factor possible that would allow all shallow water dischargers to achieve reliable compliance.

Use of Lower Detection Limit

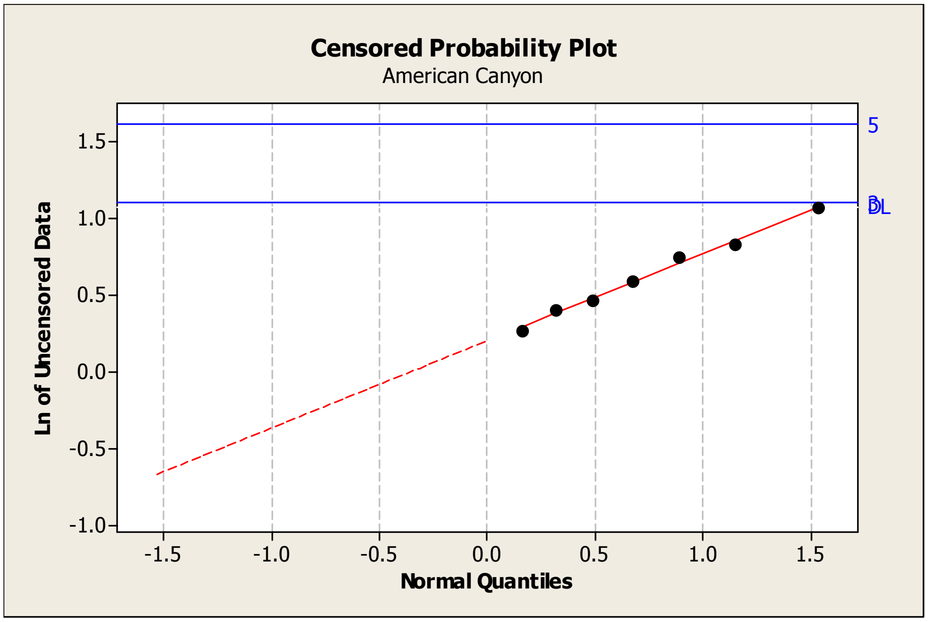
When calculating monthly average, we recommend using the method detection limit if the measurement is below the detection limit. Therefore, in addition to sampling frequency, we also encourage dischargers to use lower detection limits and report the method detection limits (instead of the reporting limits only). This will help with lowering the monthly averages when determining compliance.

Attachment 1

Lognormal Probability Plots of Cyanide Effluent Concentrations

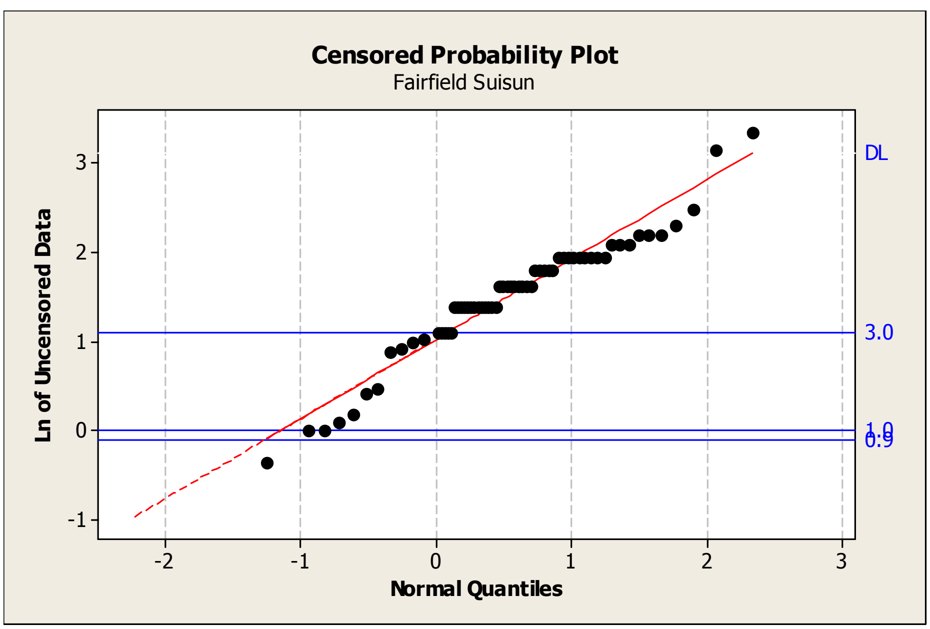
(Most Plots are Censored Probability Plots)

1. City of American Canyon



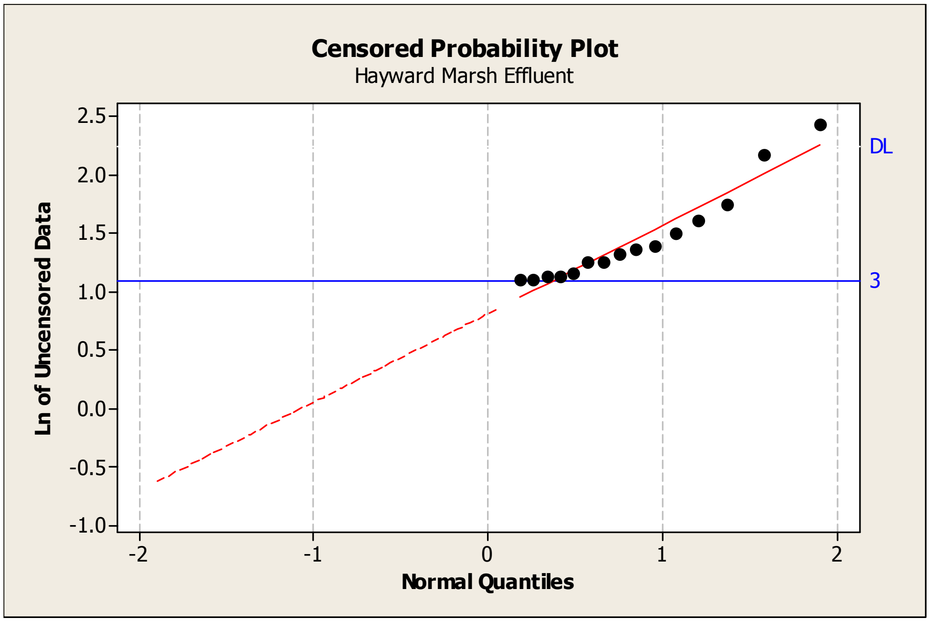
Lognormal distribution fits the data well, however, the data are too limited. There may be big deviations between the estimates and true population values.

2. Fairfield Suisun FCSD



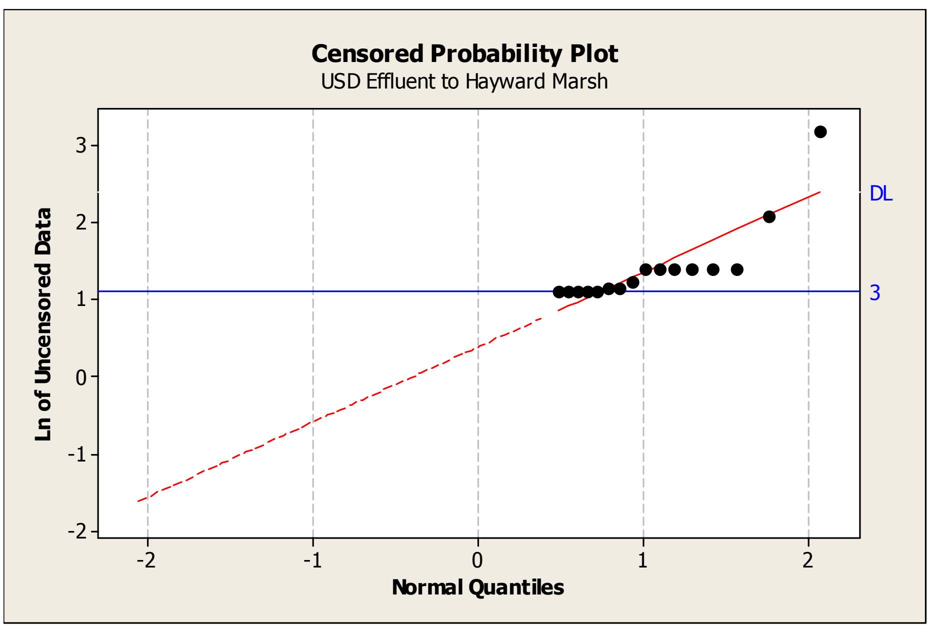
Lognormal distribution fits the data reasonably well, with small deviations. The data set is also large. Therefore, statistical estimates from this distribution fit are generally considered satisfactory.

3. Hayward Marsh Effluent



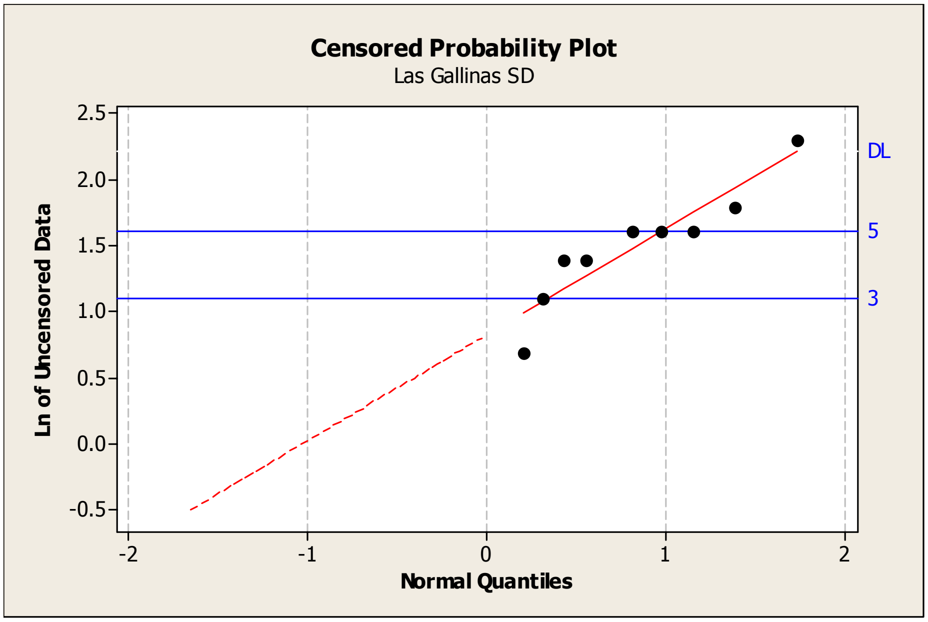
Lognormal distribution does not fit the data well. The data set is relatively small. Therefore, there will be some degrees of deviations between the statistical estimates and true population values (most likely overestimate with this method).

4. USD Effluent to Hayward Marsh



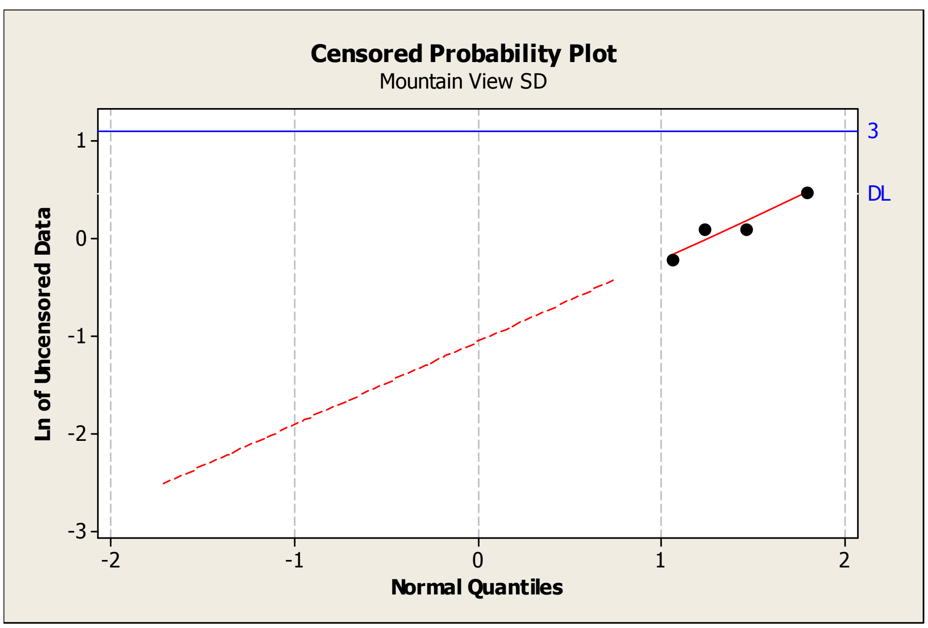
Lognormal distribution does not fit the data well. The data set is relatively small. Therefore, there will be substantial degrees of deviations between the statistical estimates and true population values (most likely overestimate with this method).

5. Las Gallinas Valley SD



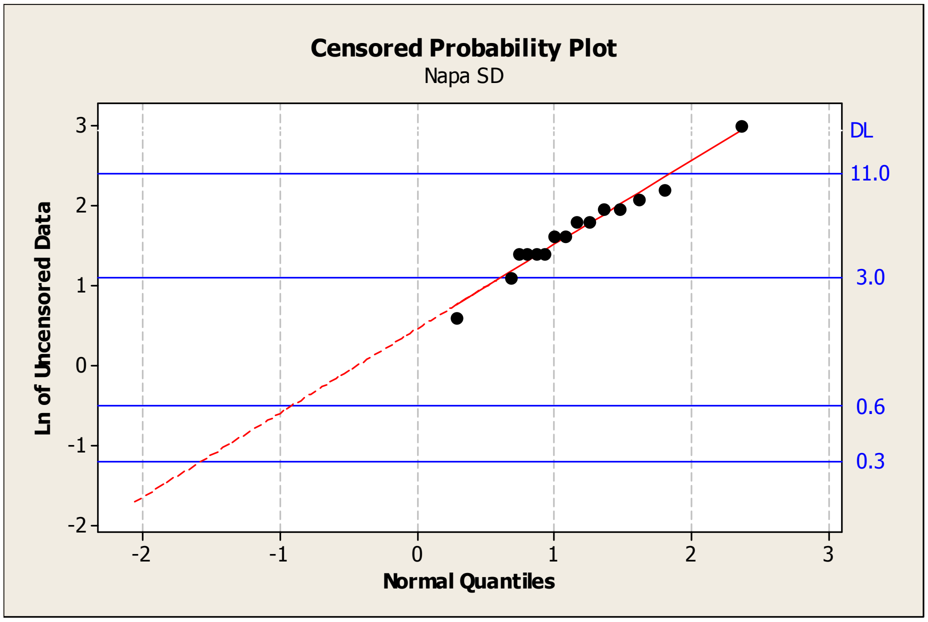
Lognormal distribution does not fit the data well. The data set is relatively small. Therefore, there will be some degrees of deviations between the statistical estimates and true population values.

6. Mountain View SD



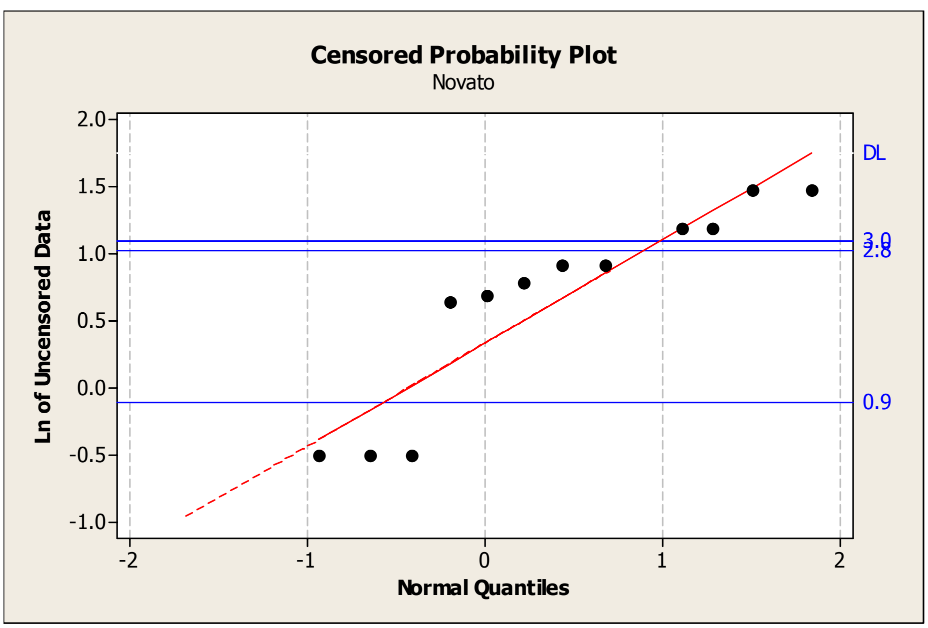
Lognormal distribution seems to fit the data well, however, the data set is too small. Therefore, it is not recommended to use this parametric method to estimate statistics.

7. Napa SD



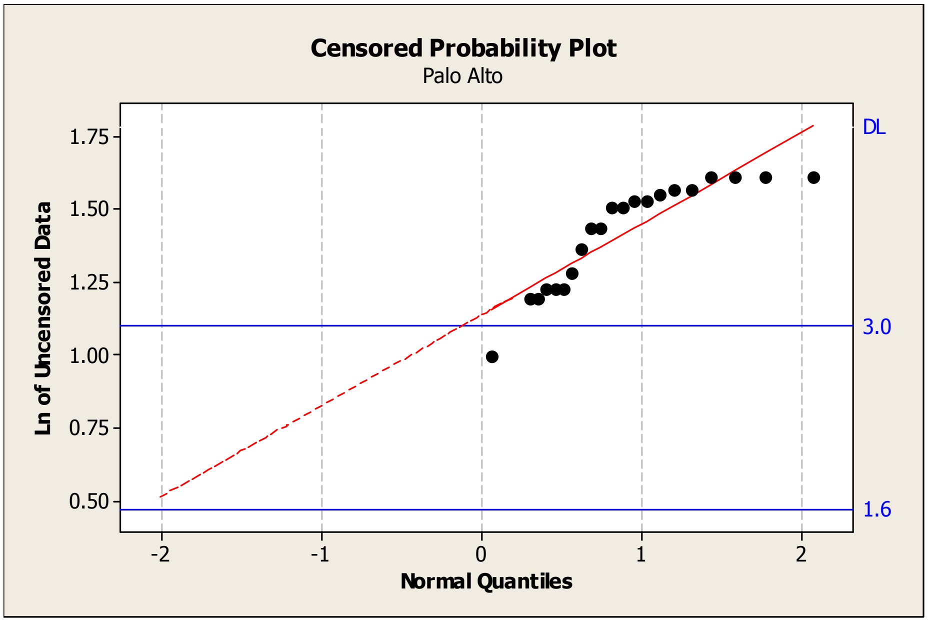
Lognormal distribution fits the data reasonably well. The data set is of medium size. Therefore, statistical estimates from this distribution fit are generally considered satisfactory.

8. Novato SD



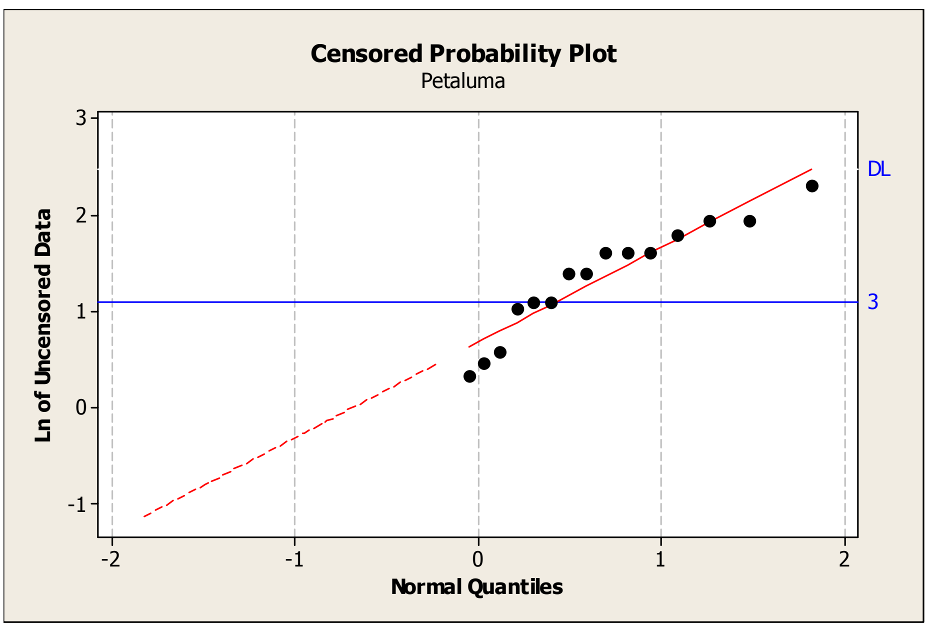
Lognormal distribution does not fit the data well. The data set is relatively small. Therefore, there will be substantial degrees of deviations between the statistical estimates and true population values.

9. Palo Alto



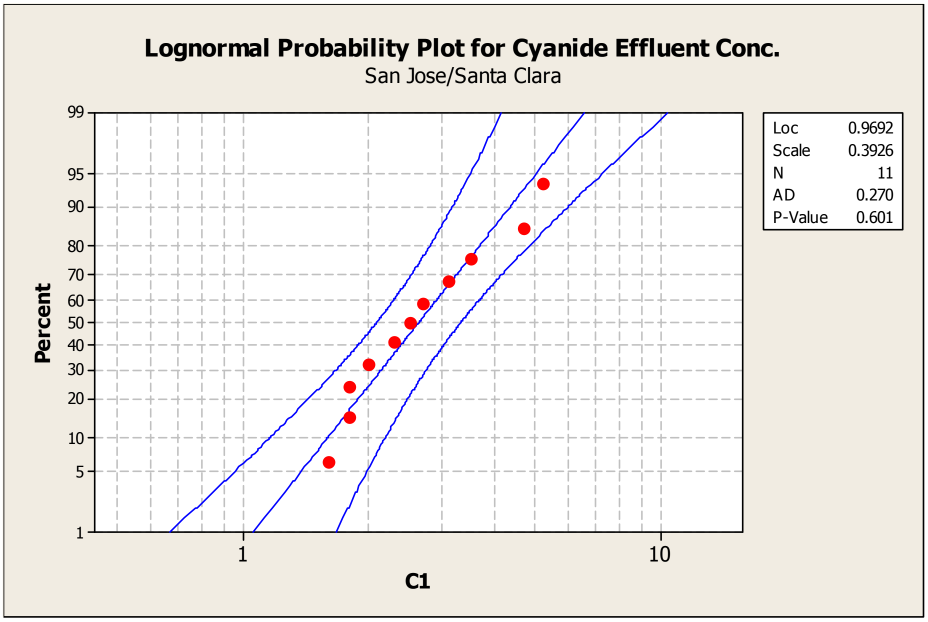
Lognormal distribution does not fit the data well. Therefore, there will be some degrees of deviations between the statistical estimates and true population values.

10. City of Petaluma



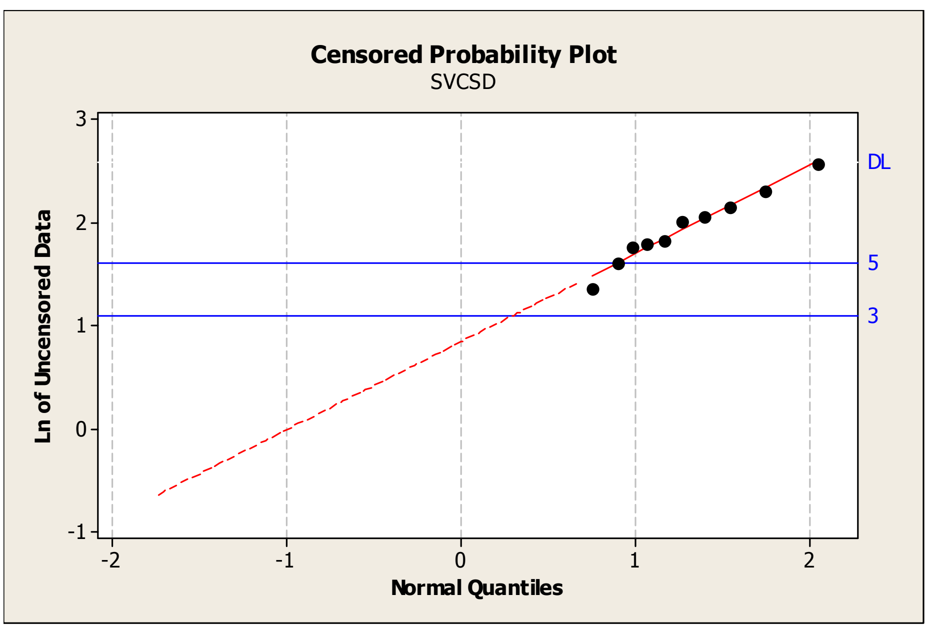
Lognormal distribution does not fit the data perfectly well, with some minor deviations. The data set is relatively small. Therefore, there will be some degrees of deviations between the statistical estimates and true population values.

11. City of San Jose/Santa Clara



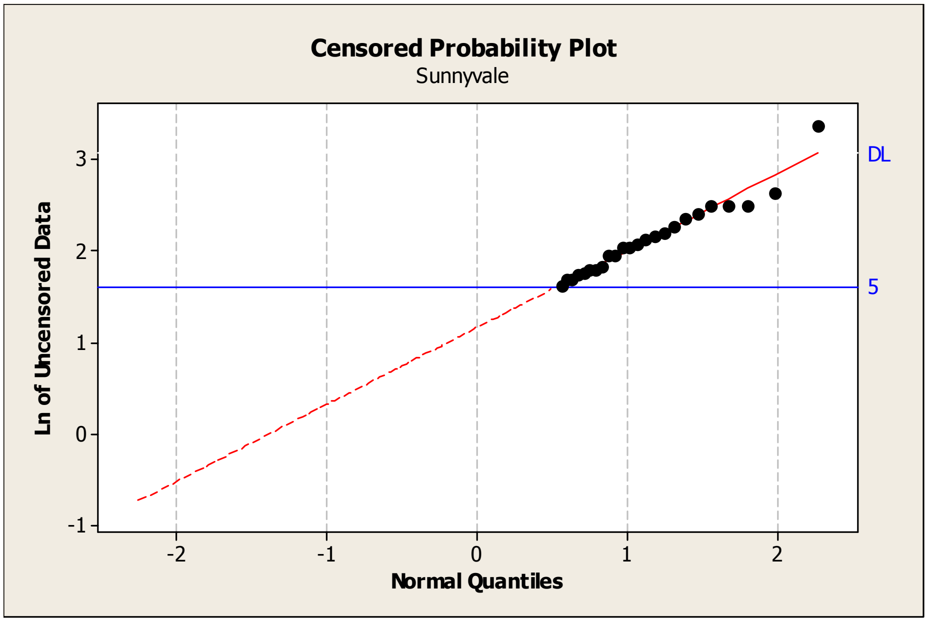
Lognormal distribution seems to fit the data well with some deviations. The data set is relatively small though. The statistical estimates are generally considered satisfactory.

12. Sonoma Valley County SD



Lognormal distribution seems to fit the data well. The data set is small though. The statistical estimates are generally considered satisfactory.

13. City of Sunnyvale



Lognormal distribution seems to fit the data well, except one extreme outlier. Therefore, there will be some degrees of deviations between the statistical estimates and true population values (the outlier will inflate the statistical estimates).

Attachment 2

Discharger	American Canyon	Fairfield-Suisun	Hayward Marsh (Effluent)	Hayward Marsh	Las Gallinas	Mt. View	Napa	Novato	Palo Alto	Petaluma	San Jose/Santa Clara	Sonoma	Sunnyvale
Acute Criteria	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4
Chronic Criteria	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
Background	0.2	0.4	0.4	0.4	0.4	0.4	0.2	0.4	0.3	0.4	0.3	0.4	0.3
Attentuation (SB04)	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25
ECA_{ac}	30.1	29.7	29.7	29.7	29.7	29.7	30.1	29.7	29.9	29.7	29.9	29.7	29.9
ECA_{ch}	9.0	8.5	8.5	8.5	8.5	8.5	9.0	8.5	8.8	8.5	8.8	8.5	8.8
CV	0.493	1.002	0.794	1.493	0.776	0.600	1.227	0.665	0.300	0.868	0.423	0.858	0.944
s	0.47	0.83	0.70	1.08	0.69	0.55	0.96	0.61	0.29	0.75	0.41	0.74	0.80
s^2	0.22	0.70	0.49	1.17	0.47	0.31	0.92	0.37	0.09	0.56	0.16	0.55	0.64
s_4	0.24	0.47	0.38	0.67	0.37	0.29	0.57	0.32	0.15	0.42	0.21	0.41	0.45
s_4^2	0.06	0.22	0.15	0.44	0.14	0.09	0.32	0.10	0.02	0.17	0.04	0.17	0.20
z	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326
$ECA_{ac,m}$	0.38	0.20	0.25	0.14	0.26	0.32	0.17	0.29	0.53	0.23	0.42	0.23	0.21
$ECA_{ch,m}$	0.59	0.37	0.44	0.27	0.45	0.53	0.32	0.50	0.71	0.41	0.63	0.42	0.39
LTA_{ac}	11.33	6.04	7.45	4.29	7.60	9.52	5.12	8.71	15.76	6.87	12.62	6.94	6.42
LTA_{ch}	5.24	3.17	3.77	2.26	3.83	4.50	2.82	4.23	6.25	3.54	5.50	3.57	3.41
LTA	5.24	3.17	3.77	2.26	3.83	4.50	2.82	4.23	6.25	3.54	5.50	3.57	3.41
s_n	0.24	0.47	0.38	0.67	0.37	0.29	0.57	0.32	0.15	0.42	0.21	0.41	0.45
s_n^2	0.06	0.22	0.15	0.44	0.14	0.09	0.32	0.10	0.02	0.17	0.04	0.17	0.20
z	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645
$AMEL_m$	1.4	1.9	1.7	2.4	1.7	1.6	2.2	1.6	1.3	1.8	1.4	1.8	1.9
s	0.47	0.83	0.70	1.08	0.69	0.55	0.96	0.61	0.29	0.75	0.41	0.74	0.80
s^2	0.22	0.70	0.49	1.17	0.47	0.31	0.92	0.37	0.09	0.56	0.16	0.55	0.64
z	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326
$MDEL_m$	2.7	4.9	4.0	6.9	3.9	3.1	5.9	3.4	1.9	4.3	2.4	4.3	4.7
AMEL	7.6	6.2	6.6	5.4	6.6	7.0	6.1	6.8	7.9	6.4	7.6	6.4	6.4
MDEL	13.9	15.6	15.0	15.6	14.9	14.0	16.6	14.4	11.9	15.3	13.0	15.2	15.9

MEC	2.9	28	11.3	24	10	1.6	20	4.43	5	10	8	13	29
Mean	1.4	3.9	2.9	2.4	3.0	0.5	2.6	1.8	3.3	2.9	2.8	3.2	4.4
Logmean	0.20	1.02	0.81	0.38	0.84	-1.06	0.47	0.35	1.14	0.67		0.85	1.16
LnSD	0.44	0.87	0.71	0.94	0.74	0.785	1.00	0.72	0.30	0.93		0.79	0.82
Mean	1.4	3.9	2.9	2.4	3.0	0.5	2.6	1.8	3.3	2.9	2.8	3.2	4.4
95th	2.5	11.7	7.3	6.9	7.8	1.3	8.3	4.6	5.1	9.1	4.9	8.7	12.3
99th	3.4	21.1	11.8	13.0	12.9	2.2	16.4	7.6	6.3	17.1	6.3	14.9	21.4
99.87th	4.6	38.0	19.1	24.6	21.3	3.7	32.3	12.3	7.6	32.1	8.1	25.4	37.1

Attachment 3

Discharger	American Canyon	Fairfield-Suisun	Hayward Marsh (Effluent)	Hayward Marsh	Las Gallinas	Mt. View	Napa	Novato	Palo Alto	Petaluma	San Jose/Santa Clara	Sonoma	Sunnyvale
Acute Criteria	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4
Chronic Criteria	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
Background	0.2	0.4	0.4	0.4	0.4	0.4	0.2	0.4	0.3	0.4	0.3	0.4	0.3
Attentuation (SB05)	3	3	3	3	3	3	3	3	3	3	3	3	3
ECA_{ac}	37.0	36.4	36.4	36.4	36.4	36.4	37.0	36.4	36.7	36.4	36.7	36.4	36.7
ECA_{ch}	11.0	10.4	10.4	10.4	10.4	10.4	11.0	10.4	10.7	10.4	10.7	10.4	10.7
CV	0.493	1.002	0.794	1.493	0.776	0.600	1.227	0.665	0.300	0.868	0.423	0.858	0.944
s	0.47	0.83	0.70	1.08	0.69	0.55	0.96	0.61	0.29	0.75	0.41	0.74	0.80
s^2	0.22	0.70	0.49	1.17	0.47	0.31	0.92	0.37	0.09	0.56	0.16	0.55	0.64
s_4	0.24	0.47	0.38	0.67	0.37	0.29	0.57	0.32	0.15	0.42	0.21	0.41	0.45
s_4^2	0.06	0.22	0.15	0.44	0.14	0.09	0.32	0.10	0.02	0.17	0.04	0.17	0.20
z	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326
$ECA_{ac,m}$	0.38	0.20	0.25	0.14	0.26	0.32	0.17	0.29	0.53	0.23	0.42	0.23	0.21
$ECA_{ch,m}$	0.59	0.37	0.44	0.27	0.45	0.53	0.32	0.50	0.71	0.41	0.63	0.42	0.39
LTA_{ac}	13.93	7.41	9.14	5.27	9.33	11.69	6.30	10.70	19.36	8.43	15.51	8.52	7.88
LTA_{ch}	6.42	3.87	4.60	2.76	4.67	5.49	3.46	5.16	7.65	4.31	6.72	4.35	4.17
LTA	6.42	3.87	4.60	2.76	4.67	5.49	3.46	5.16	7.65	4.31	6.72	4.35	4.17
s_n	0.24	0.47	0.38	0.67	0.37	0.29	0.57	0.32	0.15	0.42	0.21	0.41	0.45
s_n^2	0.06	0.22	0.15	0.44	0.14	0.09	0.32	0.10	0.02	0.17	0.04	0.17	0.20
z	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645
$AMEL_m$	1.4	1.9	1.7	2.4	1.7	1.6	2.2	1.6	1.3	1.8	1.4	1.8	1.9
s	0.47	0.83	0.70	1.08	0.69	0.55	0.96	0.61	0.29	0.75	0.41	0.74	0.80
s^2	0.22	0.70	0.49	1.17	0.47	0.31	0.92	0.37	0.09	0.56	0.16	0.55	0.64
z	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326
$MDEL_m$	2.7	4.9	4.0	6.9	3.9	3.1	5.9	3.4	1.9	4.3	2.4	4.3	4.7
AMEL	9.3	7.5	8.0	6.6	8.1	8.5	7.5	8.3	9.7	7.8	9.3	7.9	7.9
MDEL	17.0	19.0	18.3	19.1	18.2	17.1	20.3	17.6	14.5	18.6	15.9	18.6	19.4

MEC	2.9	28	11.3	24	10	1.6	20	4.43	5	10	8	13	29
Mean	1.4	3.9	2.9	2.4	3.0	0.5	2.6	1.8	3.3	2.9	2.8	3.2	4.4
Logmean	0.20	1.02	0.81	0.38	0.84	-1.06	0.47	0.35	1.14	0.67		0.85	1.16
LnSD	0.44	0.87	0.71	0.94	0.74	0.785	1.00	0.72	0.30	0.93		0.79	0.82
Mean	1.4	3.9	2.9	2.4	3.0	0.5	2.6	1.8	3.3	2.9	2.8	3.2	4.4
95th	2.5	11.7	7.3	6.9	7.8	1.3	8.3	4.6	5.1	9.1	4.9	8.7	12.3
99th	3.4	21.1	11.8	13.0	12.9	2.2	16.4	7.6	6.3	17.1	6.3	14.9	21.4
99.87th	4.6	38.0	19.1	24.6	21.3	3.7	32.3	12.3	7.6	32.1	8.1	25.4	37.1

Attachment 4

Discharger	American Canyon	Fairfield-Suisun	Hayward Marsh (Effluent)	Hayward Marsh	Las Gallinas	Mt. View	Napa	Novato	Palo Alto	Petaluma	San Jose/Santa Clara	Sonoma	Sunnyvale
Acute Criteria	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4
Chronic Criteria	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
Background	0.2	0.4	0.4	0.4	0.4	0.4	0.2	0.4	0.3	0.4	0.3	0.4	0.3
Attentuation (SB05)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
ECA_{ac}	41.6	40.9	40.9	40.9	40.9	40.9	41.6	40.9	41.3	40.9	41.3	40.9	41.3
ECA_{ch}	12.3	11.7	11.7	11.7	11.7	11.7	12.3	11.7	12.0	11.7	12.0	11.7	12.0
CV	0.493	1.002	0.794	1.493	0.776	0.600	1.227	0.665	0.300	0.868	0.423	0.858	0.944
s	0.47	0.83	0.70	1.08	0.69	0.55	0.96	0.61	0.29	0.75	0.41	0.74	0.80
s^2	0.22	0.70	0.49	1.17	0.47	0.31	0.92	0.37	0.09	0.56	0.16	0.55	0.64
s_4	0.24	0.47	0.38	0.67	0.37	0.29	0.57	0.32	0.15	0.42	0.21	0.41	0.45
s_4^2	0.06	0.22	0.15	0.44	0.14	0.09	0.32	0.10	0.02	0.17	0.04	0.17	0.20
z	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326
$ECA_{ac,m}$	0.38	0.20	0.25	0.14	0.26	0.32	0.17	0.29	0.53	0.23	0.42	0.23	0.21
$ECA_{ch,m}$	0.59	0.37	0.44	0.27	0.45	0.53	0.32	0.50	0.71	0.41	0.63	0.42	0.39
LTA_{ac}	15.66	8.33	10.27	5.92	10.48	13.13	7.08	12.02	21.76	9.48	17.43	9.58	8.86
LTA_{ch}	7.21	4.33	5.15	3.09	5.23	6.14	3.88	5.78	8.58	4.83	7.54	4.87	4.68
LTA	7.21	4.33	5.15	3.09	5.23	6.14	3.88	5.78	8.58	4.83	7.54	4.87	4.68
s_n	0.24	0.47	0.38	0.67	0.37	0.29	0.57	0.32	0.15	0.42	0.21	0.41	0.45
s_n^2	0.06	0.22	0.15	0.44	0.14	0.09	0.32	0.10	0.02	0.17	0.04	0.17	0.20
z	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645
$AMEL_m$	1.4	1.9	1.7	2.4	1.7	1.6	2.2	1.6	1.3	1.8	1.4	1.8	1.9
s	0.47	0.83	0.70	1.08	0.69	0.55	0.96	0.61	0.29	0.75	0.41	0.74	0.80
s^2	0.22	0.70	0.49	1.17	0.47	0.31	0.92	0.37	0.09	0.56	0.16	0.55	0.64
z	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326
$MDEL_m$	2.7	4.9	4.0	6.9	3.9	3.1	5.9	3.4	1.9	4.3	2.4	4.3	4.7
AMEL	10.4	8.4	9.0	7.4	9.0	9.5	8.4	9.3	10.8	8.8	10.4	8.8	8.8
MDEL	19.1	21.3	20.5	21.3	20.4	19.1	22.8	19.7	16.3	20.9	17.8	20.8	21.8

MEC	2.9	28	11.3	24	10	1.6	20	4.43	5	10	8	13	29
Mean	1.4	3.9	2.9	2.4	3.0	0.5	2.6	1.8	3.3	2.9	2.8	3.2	4.4
Logmean	0.20	1.02	0.81	0.38	0.84	-1.06	0.47	0.35	1.14	0.67		0.85	1.16
LnSD	0.44	0.87	0.71	0.94	0.74	0.785	1.00	0.72	0.30	0.93		0.79	0.82
Mean	1.4	3.9	2.9	2.4	3.0	0.5	2.6	1.8	3.3	2.9	2.8	3.2	4.4
95th	2.5	11.7	7.3	6.9	7.8	1.3	8.3	4.6	5.1	9.1	4.9	8.7	12.3
99th	3.4	21.1	11.8	13.0	12.9	2.2	16.4	7.6	6.3	17.1	6.3	14.9	21.4
99.87th	4.6	38.0	19.1	24.6	21.3	3.7	32.3	12.3	7.6	32.1	8.1	25.4	37.1

Attachment 5

Discharger	American Canyon	Fairfield-Suisun	Hayward Marsh (Effluent)	Hayward Marsh	Las Gallinas	Mt. View	Napa	Novato	Palo Alto	Petaluma	San Jose/Santa Clara	Sonoma	Sunnyvale
Acute Criteria	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4
Chronic Criteria	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
Background	0.2	0.4	0.4	0.4	0.4	0.4	0.2	0.4	0.3	0.4	0.3	0.4	0.3
Attentuation (SB05)	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
ECA_{ac}	50.8	49.9	49.9	49.9	49.9	49.9	50.8	49.9	50.4	49.9	50.4	49.9	50.4
ECA_{ch}	15.0	14.2	14.2	14.2	14.2	14.2	15.0	14.2	14.6	14.2	14.6	14.2	14.6
CV	0.493	1.002	0.794	1.493	0.776	0.600	1.227	0.665	0.300	0.868	0.423	0.858	0.944
s	0.47	0.83	0.70	1.08	0.69	0.55	0.96	0.61	0.29	0.75	0.41	0.74	0.80
s^2	0.22	0.70	0.49	1.17	0.47	0.31	0.92	0.37	0.09	0.56	0.16	0.55	0.64
s_4	0.24	0.47	0.38	0.67	0.37	0.29	0.57	0.32	0.15	0.42	0.21	0.41	0.45
s_4^2	0.06	0.22	0.15	0.44	0.14	0.09	0.32	0.10	0.02	0.17	0.04	0.17	0.20
z	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326
$ECA_{ac,m}$	0.38	0.20	0.25	0.14	0.26	0.32	0.17	0.29	0.53	0.23	0.42	0.23	0.21
$ECA_{ch,m}$	0.59	0.37	0.44	0.27	0.45	0.53	0.32	0.50	0.71	0.41	0.63	0.42	0.39
LTA_{ac}	19.12	10.16	12.53	7.23	12.79	16.02	8.65	14.67	26.56	11.56	21.28	11.68	10.81
LTA_{ch}	8.78	5.26	6.25	3.76	6.35	7.46	4.73	7.02	10.44	5.87	9.17	5.92	5.69
LTA	8.78	5.26	6.25	3.76	6.35	7.46	4.73	7.02	10.44	5.87	9.17	5.92	5.69
s_n	0.24	0.47	0.38	0.67	0.37	0.29	0.57	0.32	0.15	0.42	0.21	0.41	0.45
s_n^2	0.06	0.22	0.15	0.44	0.14	0.09	0.32	0.10	0.02	0.17	0.04	0.17	0.20
z	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645
$AMEL_m$	1.4	1.9	1.7	2.4	1.7	1.6	2.2	1.6	1.3	1.8	1.4	1.8	1.9
s	0.47	0.83	0.70	1.08	0.69	0.55	0.96	0.61	0.29	0.75	0.41	0.74	0.80
s^2	0.22	0.70	0.49	1.17	0.47	0.31	0.92	0.37	0.09	0.56	0.16	0.55	0.64
z	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326
$MDEL_m$	2.7	4.9	4.0	6.9	3.9	3.1	5.9	3.4	1.9	4.3	2.4	4.3	4.7
AMEL	12.7	10.3	10.9	9.0	11.0	11.6	10.2	11.3	13.2	10.7	12.7	10.7	10.8
MDEL	23.3	25.9	24.9	25.9	24.8	23.2	27.8	23.9	19.8	25.3	21.7	25.3	26.5

MEC	2.9	28	11.3	24	10	1.6	20	4.43	5	10	8	13	29
Mean	1.4	3.9	2.9	2.4	3.0	0.5	2.6	1.8	3.3	2.9	2.8	3.2	4.4
Logmean	0.20	1.02	0.81	0.38	0.84	-1.06	0.47	0.35	1.14	0.67		0.85	1.16
LnSD	0.44	0.87	0.71	0.94	0.74	0.785	1.00	0.72	0.30	0.93		0.79	0.82
Mean	1.4	3.9	2.9	2.4	3.0	0.5	2.6	1.8	3.3	2.9	2.8	3.2	4.4
95th	2.5	11.7	7.3	6.9	7.8	1.3	8.3	4.6	5.1	9.1	4.9	8.7	12.3
99th	3.4	21.1	11.8	13.0	12.9	2.2	16.4	7.6	6.3	17.1	6.3	14.9	21.4
99.87th	4.6	38.0	19.1	24.6	21.3	3.7	32.3	12.3	7.6	32.1	8.1	25.4	37.1

Attachment 6

Time Series Plots of Cyanide Effluent Concentrations

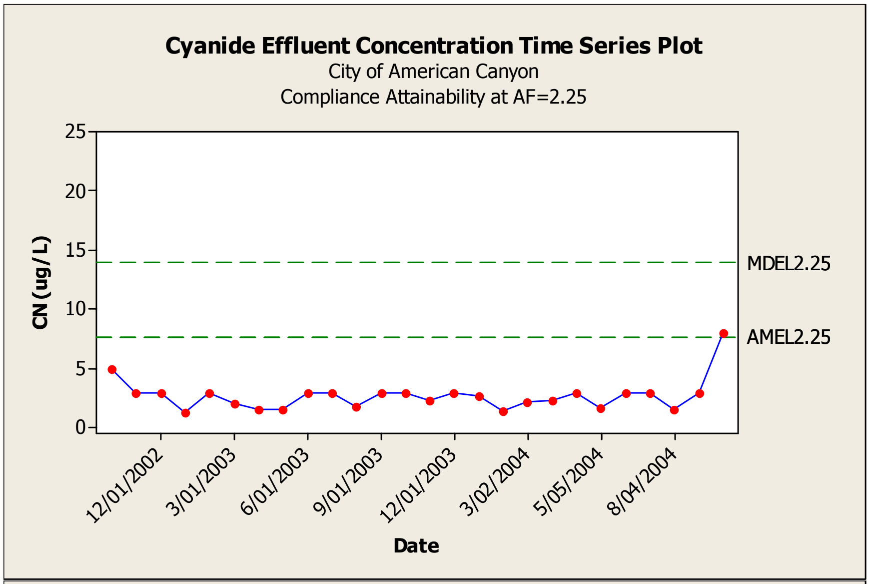
and

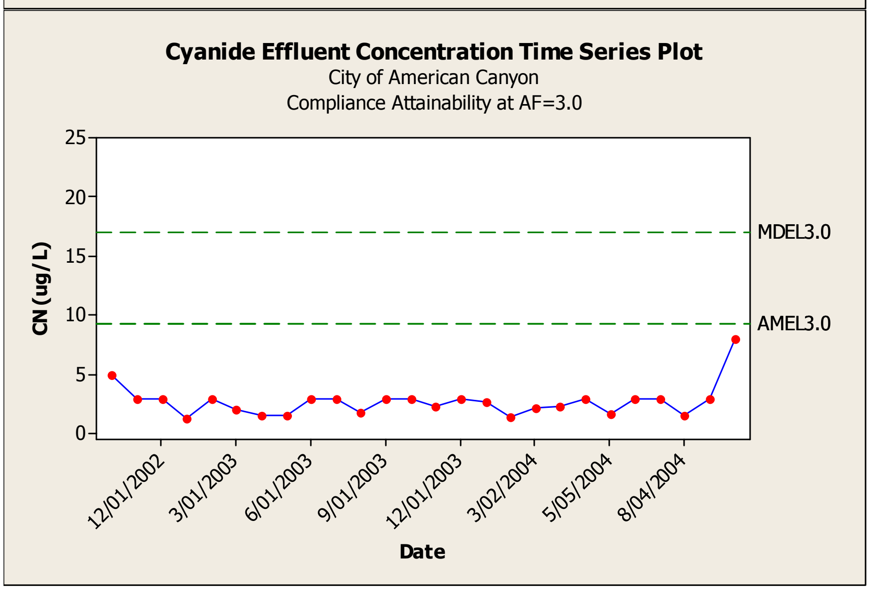
Average Monthly Effluent Limitation (AMEL)/

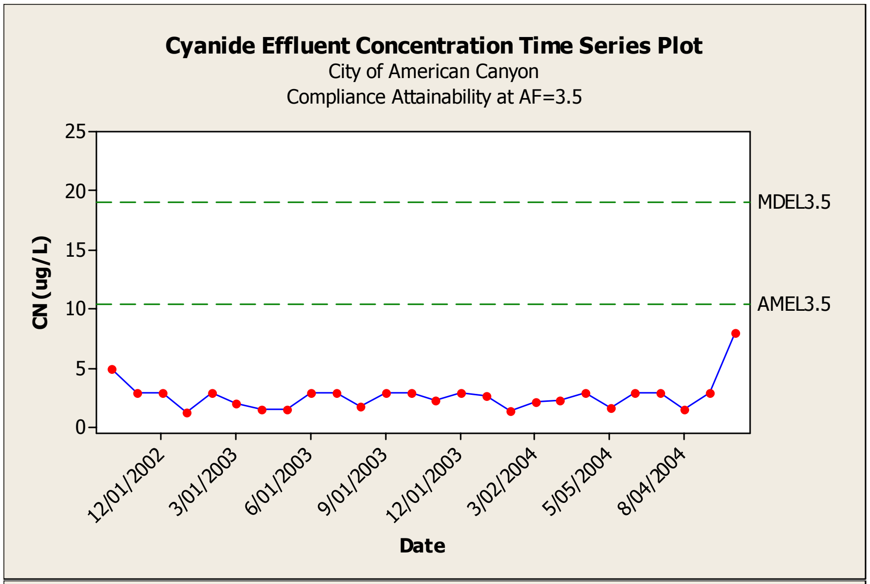
Maximum Daily Effluent Limitation (MDEL)

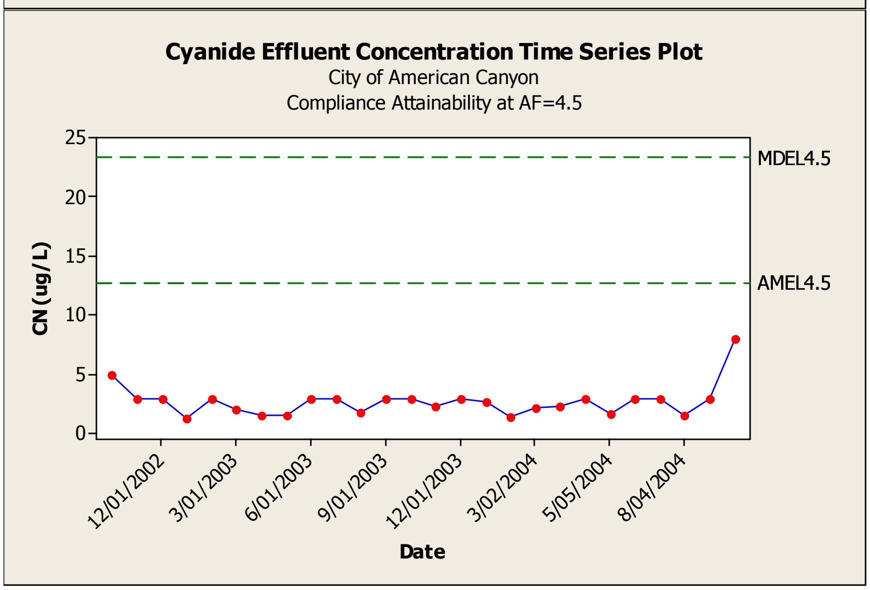
for the Attenuation Factor (AF) = 2.25, 3.0, 3.5, and 4.5

1. City of American Canyon

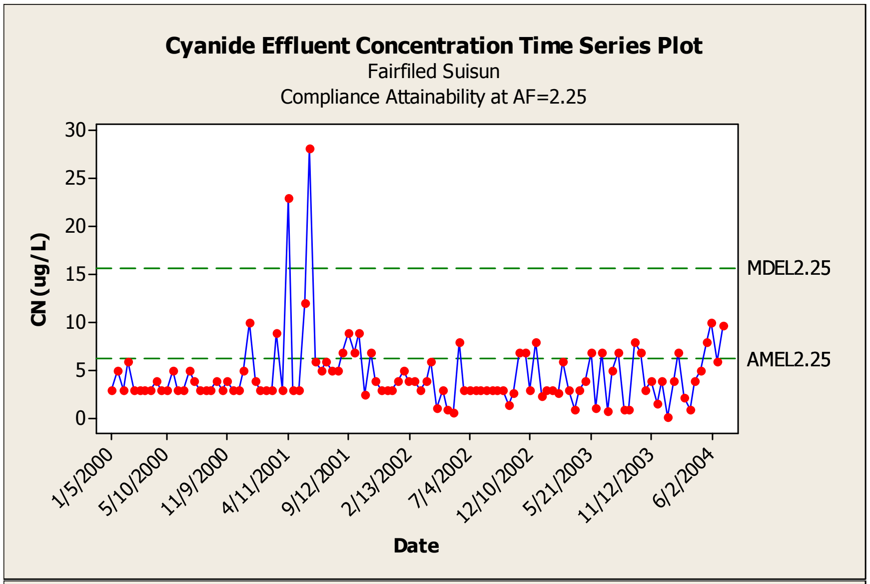


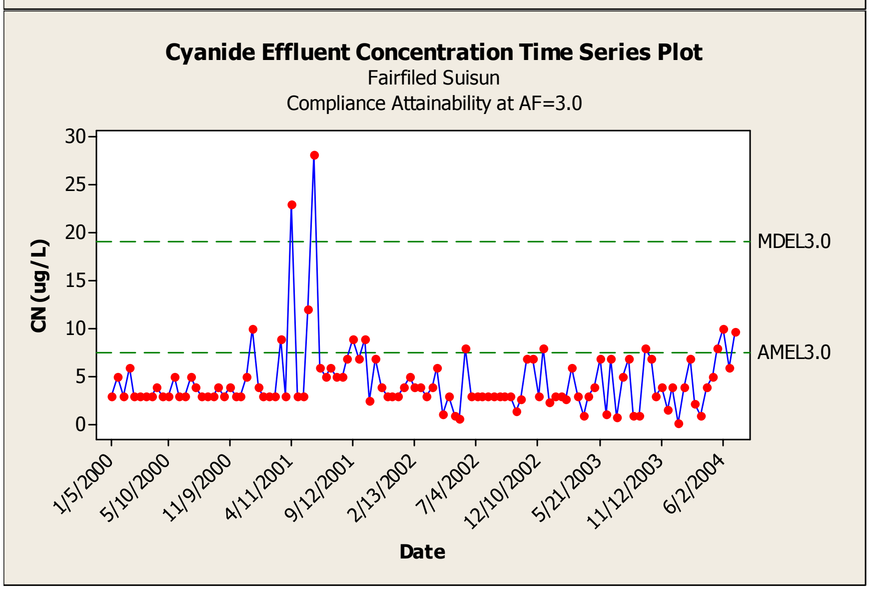


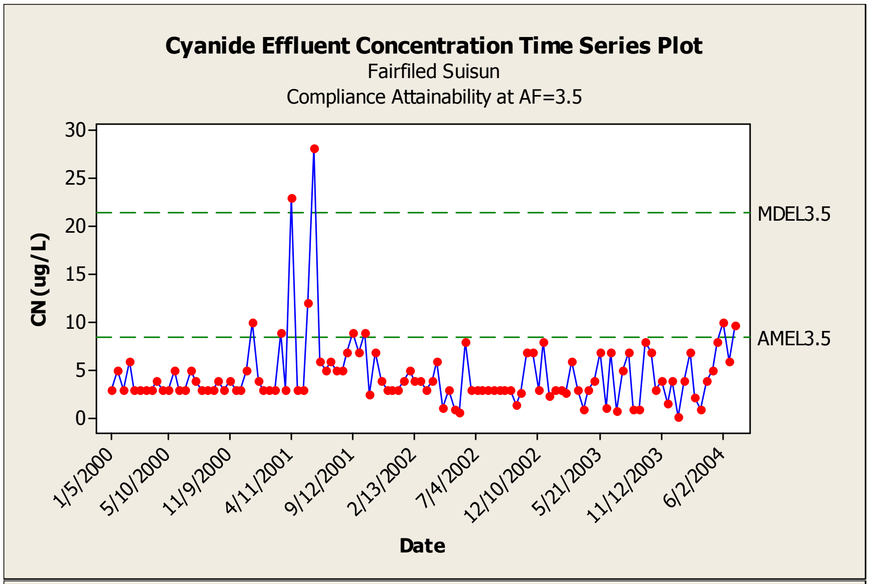

Cyanide Effluent Concentration Time Series Plot
City of American Canyon
Compliance Attainability at AF=3.5
CN (ug/L)
25
20
15
10
5
0
MDEL3.5
AMEL3.5
12/01/2002
3/01/2003
6/01/2003
9/01/2003
12/01/2003
3/02/2004
5/05/2004
8/04/2004
Date

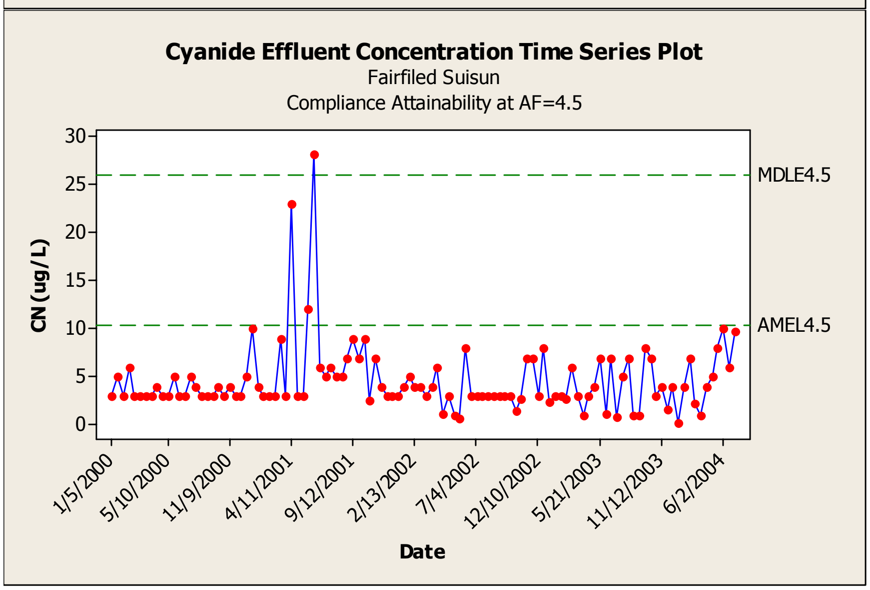

Cyanide Effluent Concentration Time Series Plot
City of American Canyon
Compliance Attainability at AF=4.5
CN (ug/L)
25
20
15
10
5
0
MDEL4.5
AMEL4.5
12/01/2002
3/01/2003
6/01/2003
9/01/2003
12/01/2003
3/02/2004
5/05/2004
8/04/2004
Date

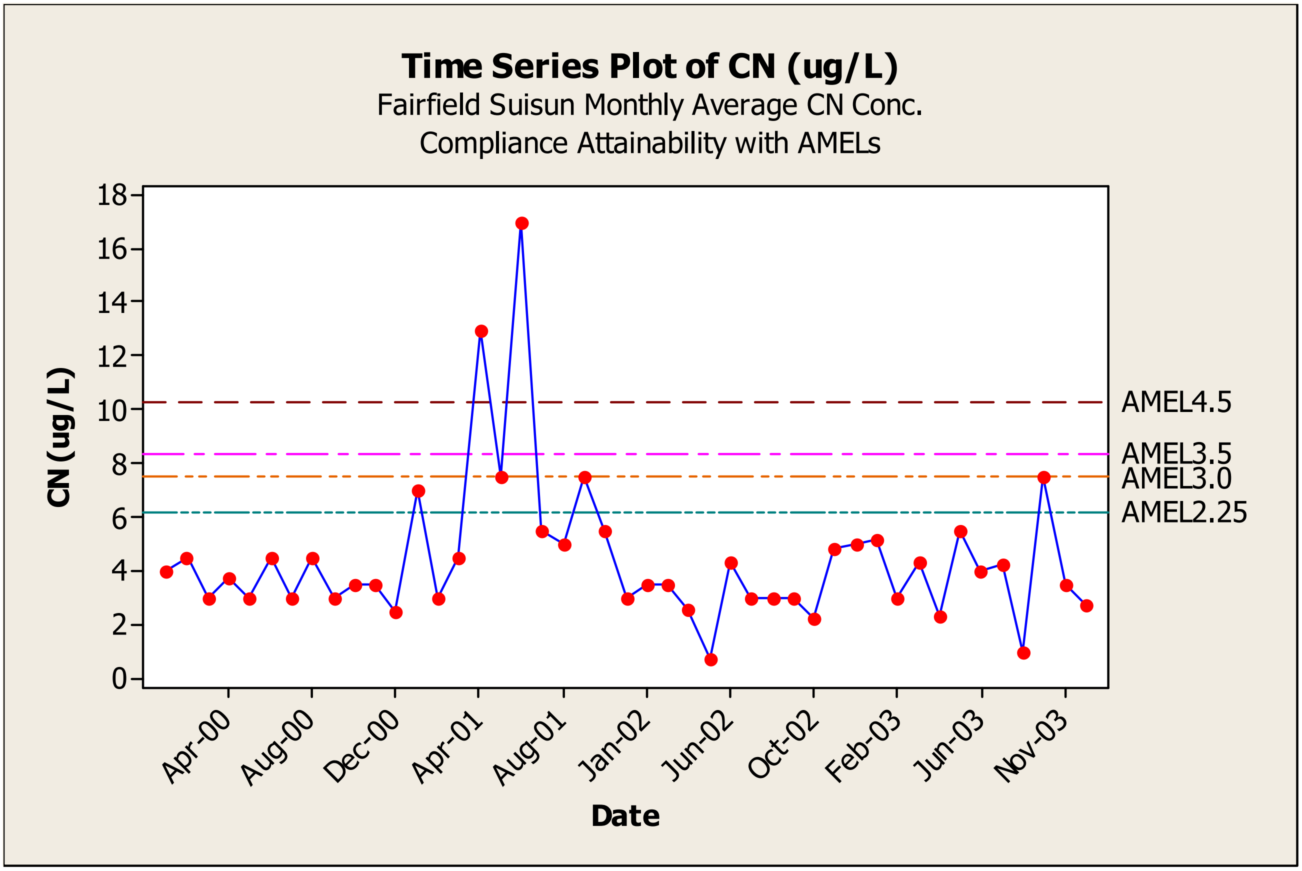
2. Fairfield Suisun



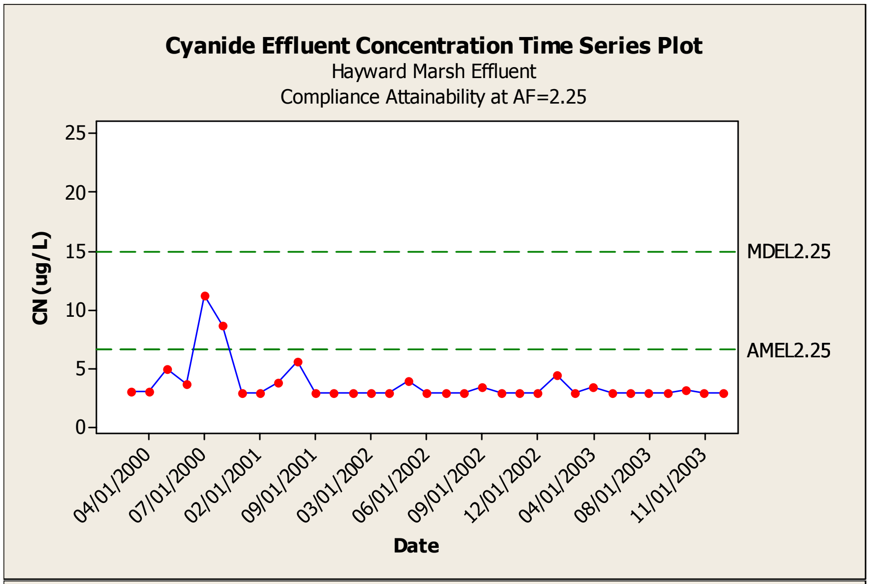


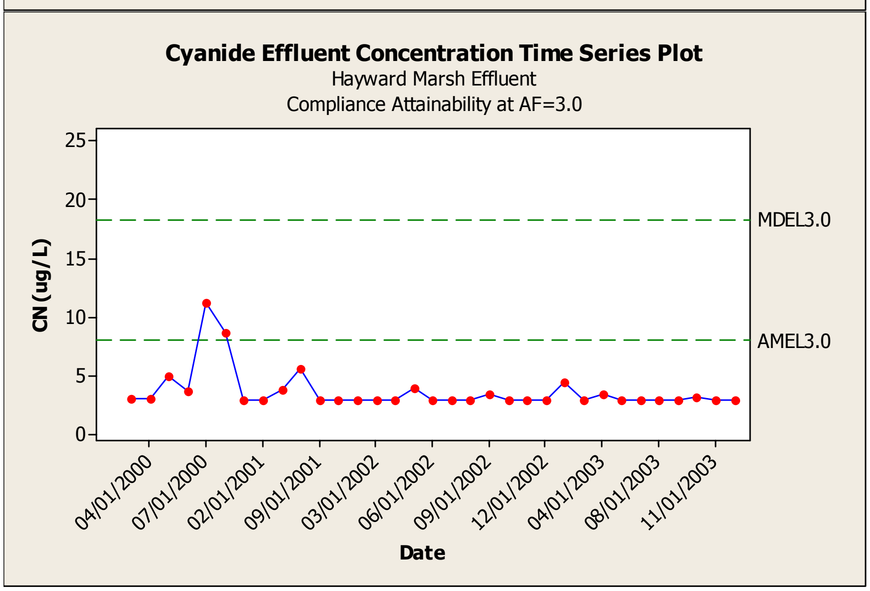

Cyanide Effluent Concentration Time Series Plot
Fairfiled Suisun
Compliance Attainability at AF=3.5
CN (ug/L)
MDEL3.5
AMEL3.5
1/5/2000
5/10/2000
11/9/2000
4/11/2001
9/12/2001
2/13/2002
7/4/2002
12/10/2002
5/21/2003
11/12/2003
6/2/2004
Date

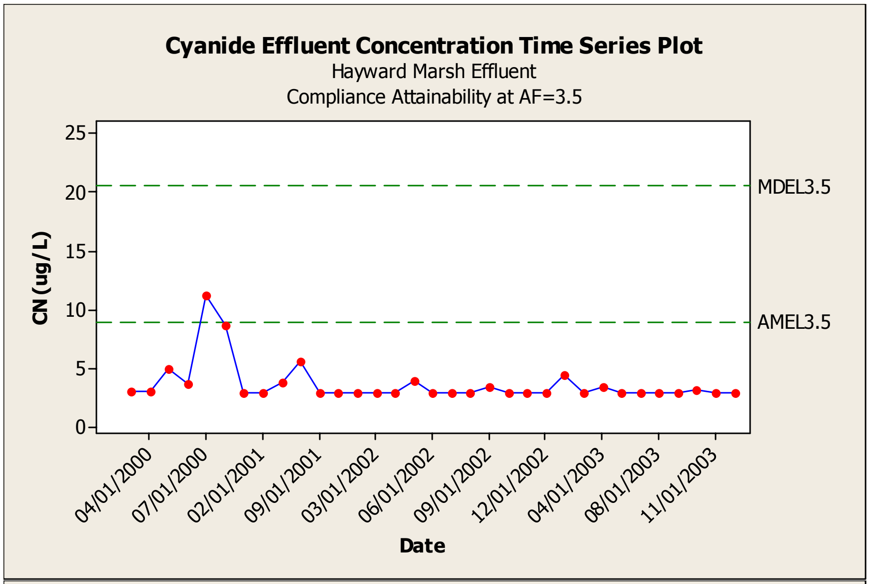

Cyanide Effluent Concentration Time Series Plot
Fairfiled Suisun
Compliance Attainability at AF=4.5
CN (ug/L)
MDLE4.5
AMEL4.5
1/5/2000
5/10/2000
11/9/2000
4/11/2001
9/12/2001
2/13/2002
7/4/2002
12/10/2002
5/21/2003
11/12/2003
6/2/2004
Date

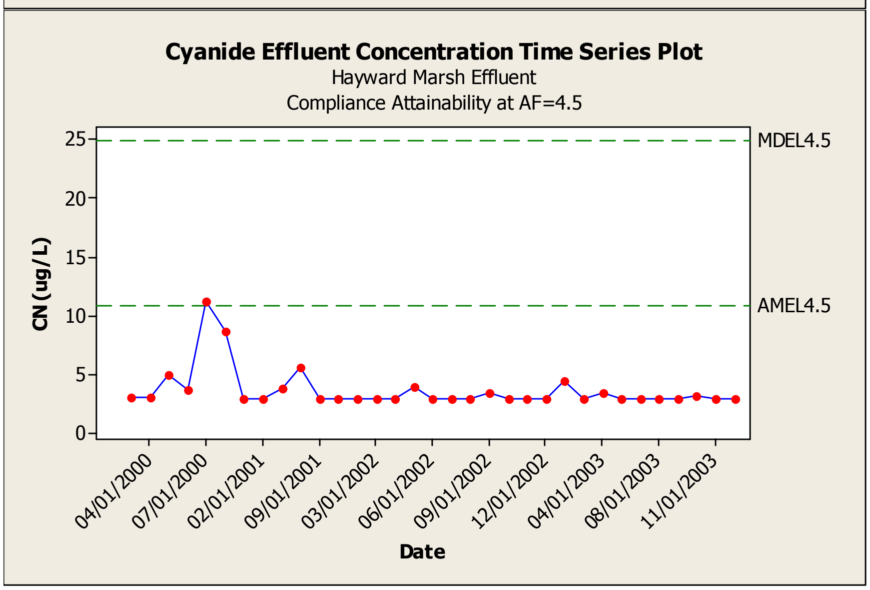

Time Series Plot of CN (ug/L)
Fairfield Suisun Monthly Average CN Conc.
Compliance Attainability with AMELs
CN (ug/L)
0
2
4
6
8
10
12
14
16
18
AMEL4.5
AMEL3.5
AMEL3.0
AMEL2.25
Apr-00
Aug-00
Dec-00
Apr-01
Aug-01
Jan-02
Jun-02
Oct-02
Feb-03
Jun-03
Nov-03
Date

3. Hayward Marsh Effluent

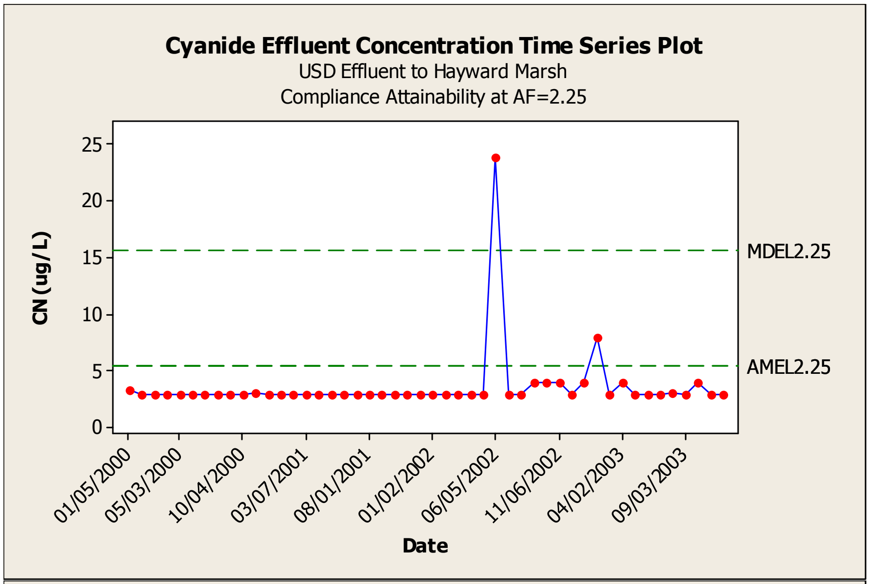


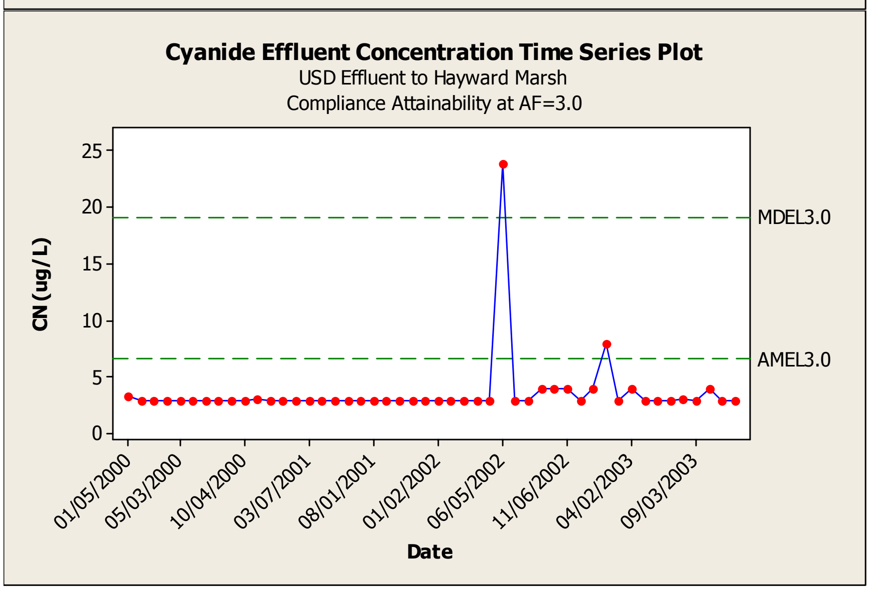


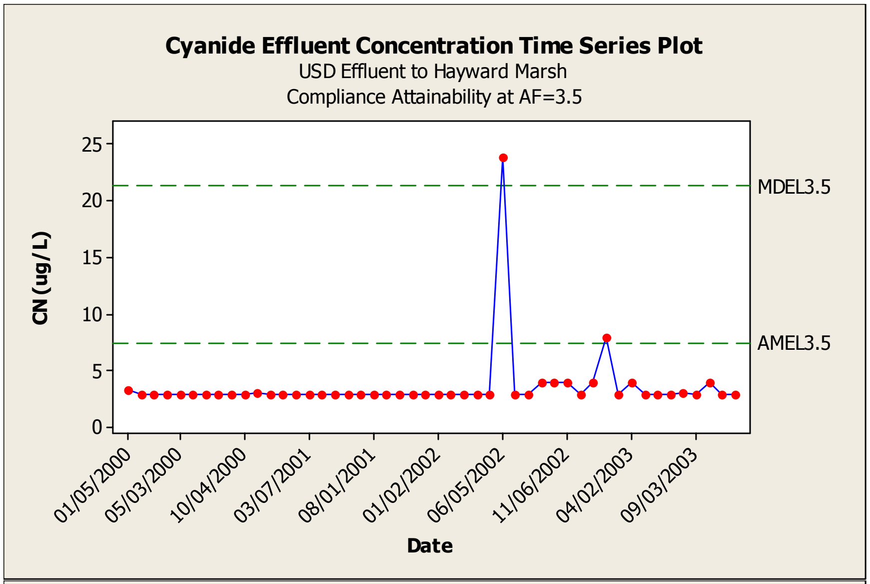

Cyanide Effluent Concentration Time Series Plot
Hayward Marsh Effluent
Compliance Attainability at AF=3.5
CN (ug/L)
MDEL3.5
AMEL3.5
0
5
10
15
20
25
04/01/2000
07/01/2000
02/01/2001
09/01/2001
03/01/2002
06/01/2002
09/01/2002
12/01/2002
04/01/2003
08/01/2003
11/01/2003
Date

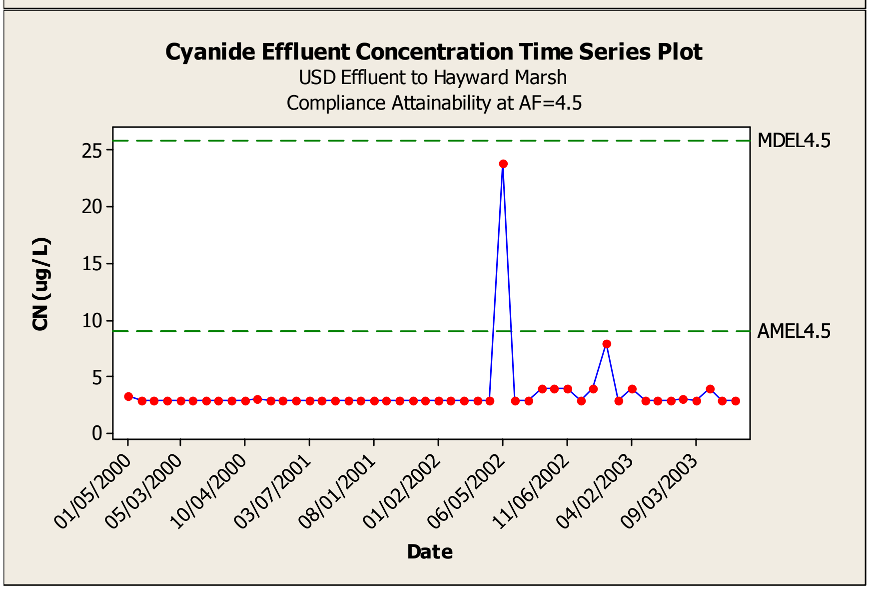

Cyanide Effluent Concentration Time Series Plot
Hayward Marsh Effluent
Compliance Attainability at AF=4.5
CN (ug/L)
MDEL4.5
AMEL4.5
0
5
10
15
20
25
04/01/2000
07/01/2000
02/01/2001
09/01/2001
03/01/2002
06/01/2002
09/01/2002
12/01/2002
04/01/2003
08/01/2003
11/01/2003
Date

4. USD Effluent to Hayward Marsh






Cyanide Effluent Concentration Time Series Plot
USD Effluent to Hayward Marsh
Compliance Attainability at AF=3.5
CN (ug/L)
25
20
15
10
5
0
MDEL3.5
AMEL3.5
01/05/2000
05/03/2000
10/04/2000
03/07/2001
08/01/2001
01/02/2002
06/05/2002
11/06/2002
04/02/2003
09/03/2003
Date


Cyanide Effluent Concentration Time Series Plot
USD Effluent to Hayward Marsh
Compliance Attainability at AF=4.5
CN (ug/L)
25
20
15
10
5
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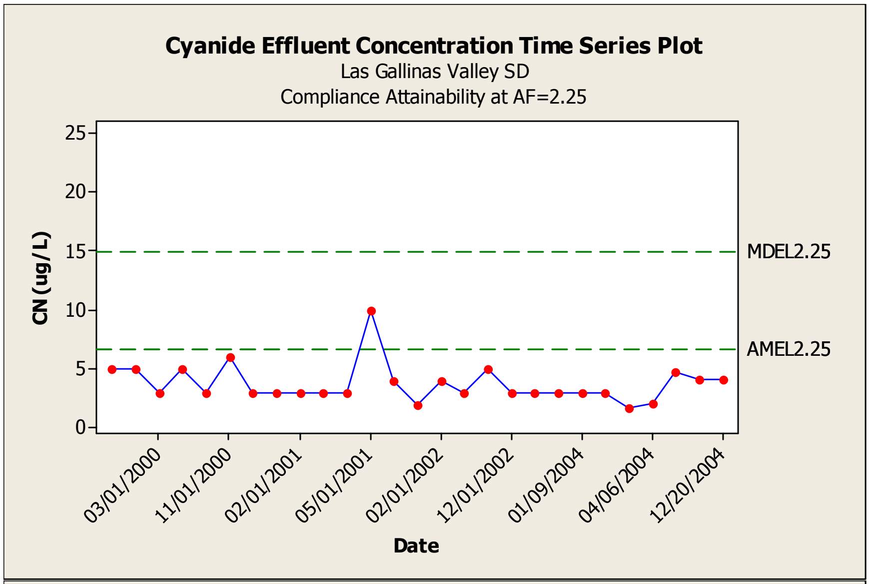
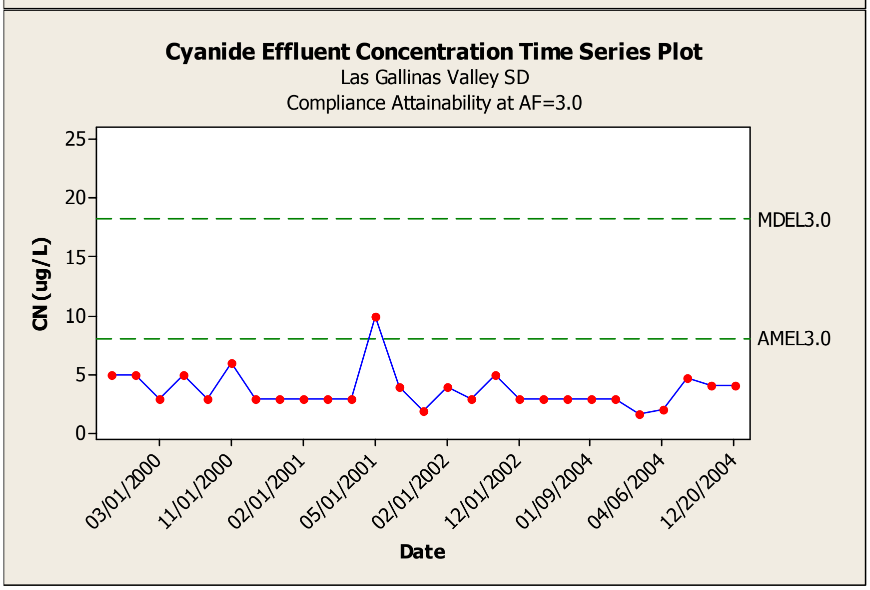
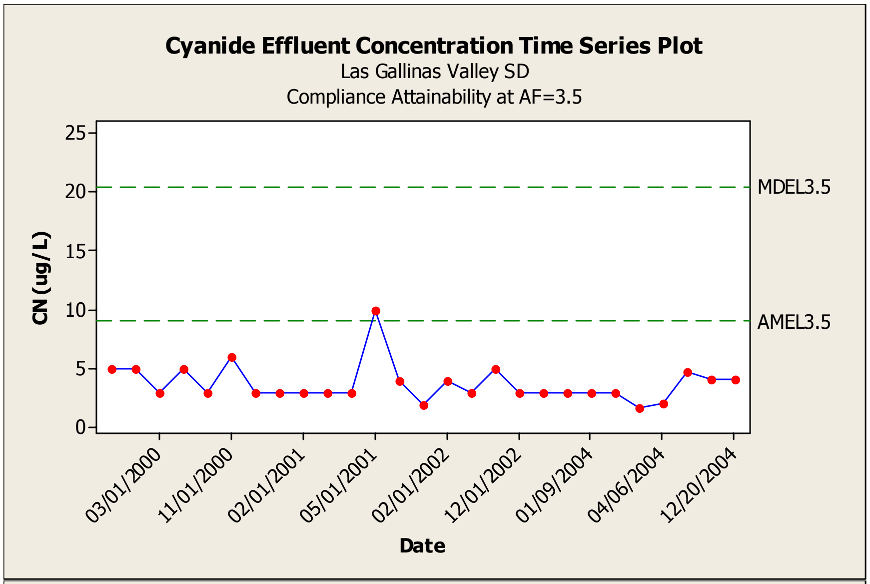
MDEL4.5
AMEL4.5
01/05/2000
05/03/2000
10/04/2000
03/07/2001
08/01/2001
01/02/2002
06/05/2002
11/06/2002
04/02/2003
09/03/2003
Date

5. Las Gallinas Valley Sanitary District







Cyanide Effluent Concentration Time Series Plot
Las Gallinas Valley SD
Compliance Attainability at AF=3.5
CN (ug/L)
25
20
15
10
5
0
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AMEL3.5
03/01/2000
11/01/2000
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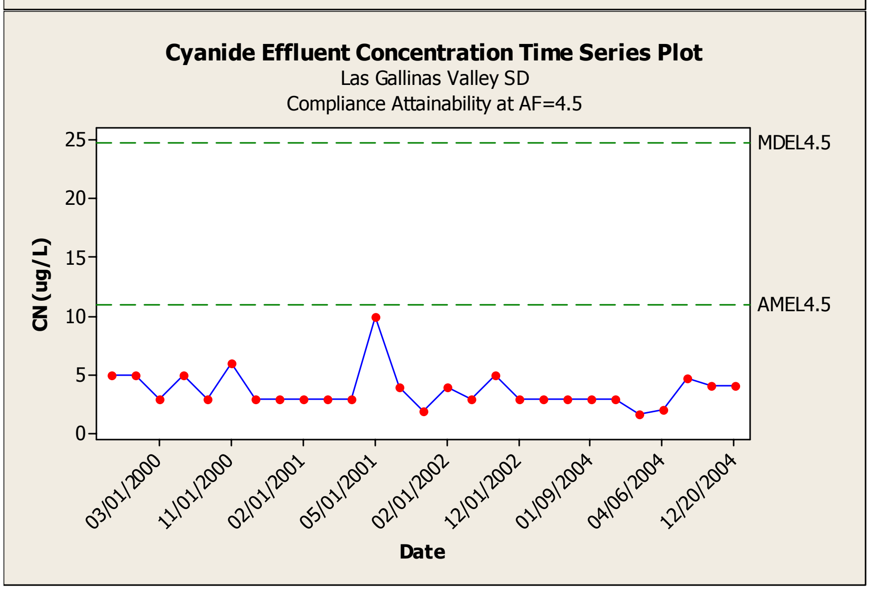
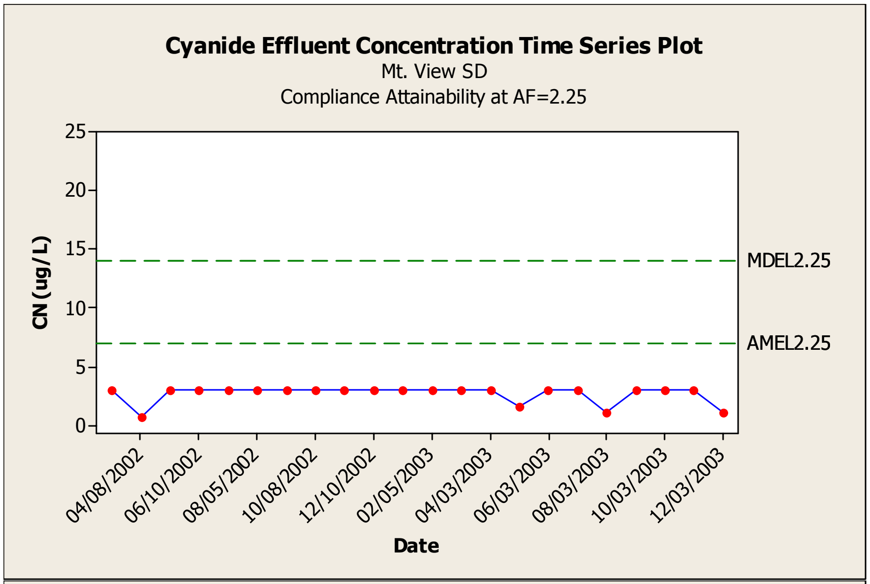
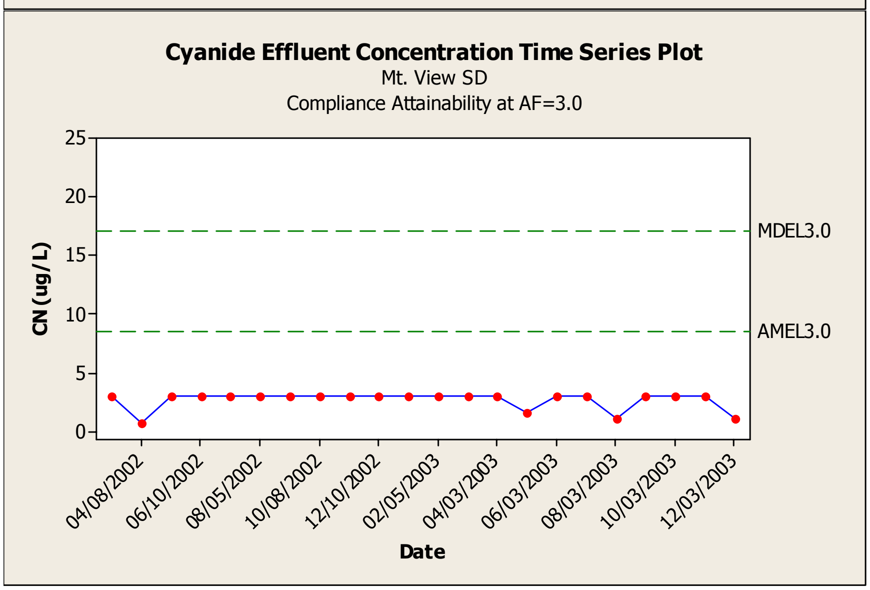
05/01/2001
02/01/2002
12/01/2002
01/09/2004
04/06/2004
12/20/2004
Date

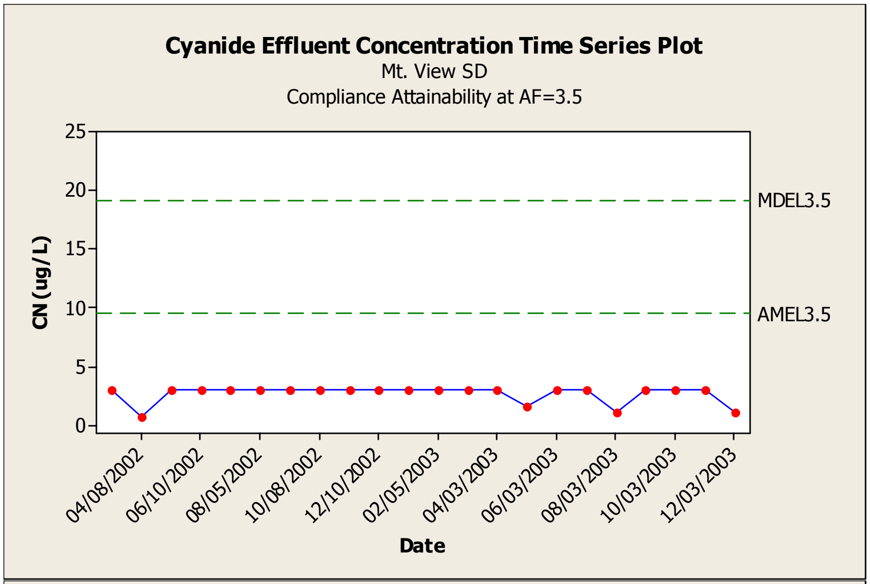


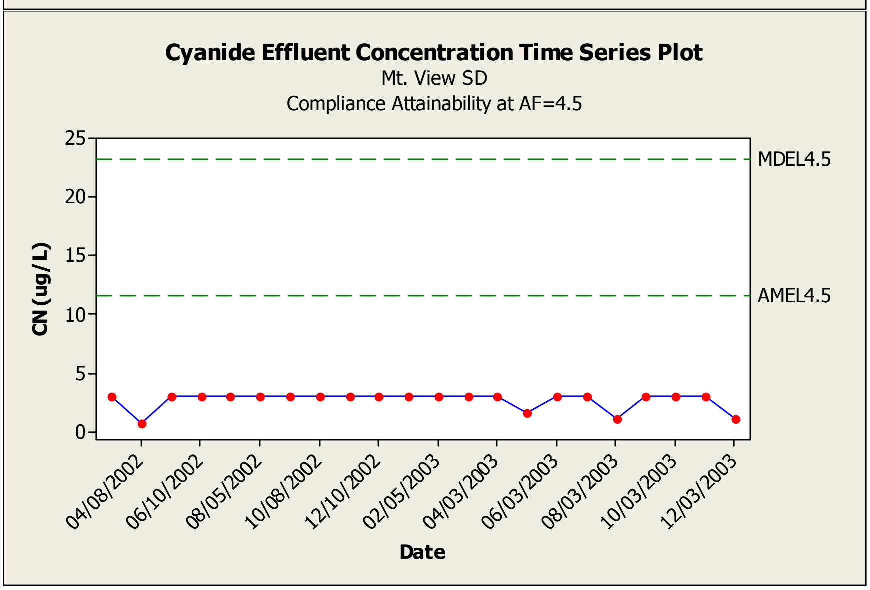
Cyanide Effluent Concentration Time Series Plot
Las Gallinas Valley SD
Compliance Attainability at AF=4.5
CN (ug/L)
25
20
15
10
5
0
MDEL4.5
AMEL4.5
03/01/2000
11/01/2000
02/01/2001
05/01/2001
02/01/2002
12/01/2002
01/09/2004
04/06/2004
12/20/2004
Date

6. Mountain View Sanitary District (Martinez)






Cyanide Effluent Concentration Time Series Plot
Mt. View SD
Compliance Attainability at AF=3.5
CN (ug/L)
0
5
10
15
20
25
MDEL3.5
AMEL3.5
04/08/2002
06/10/2002
08/05/2002
10/08/2002
12/10/2002
02/05/2003
04/03/2003
06/03/2003
08/03/2003
10/03/2003
12/03/2003
Date


Cyanide Effluent Concentration Time Series Plot
Mt. View SD
Compliance Attainability at AF=4.5
CN (ug/L)
0
5
10
15
20
25
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AMEL4.5
04/08/2002
06/10/2002
08/05/2002
10/08/2002
12/10/2002
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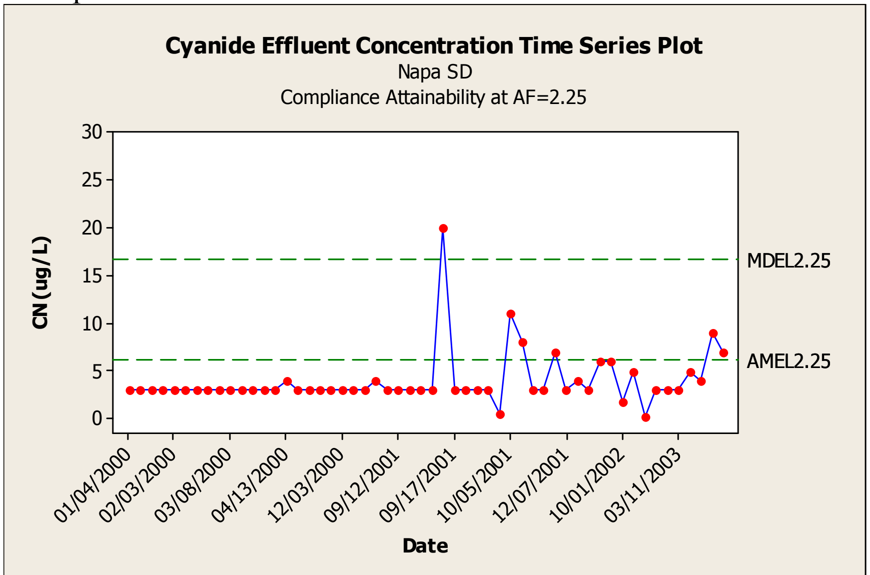
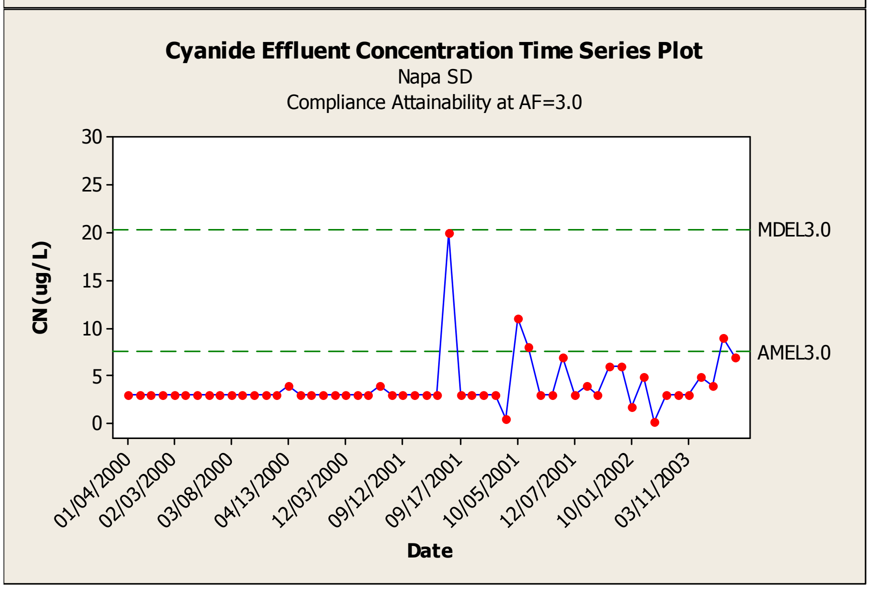
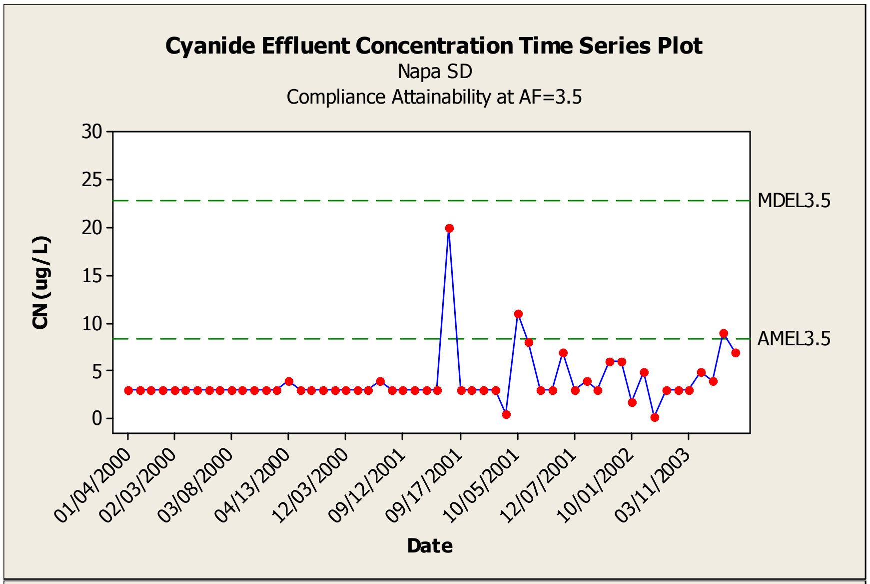
04/03/2003
06/03/2003
08/03/2003
10/03/2003
12/03/2003
Date

7. Napa Sanitation District






Cyanide Effluent Concentration Time Series Plot
Napa SD
Compliance Attainability at AF=3.5
CN (ug/L)
30
25
20
15
10
5
0
MDEL3.5
AMEL3.5
01/04/2000
02/03/2000
03/08/2000
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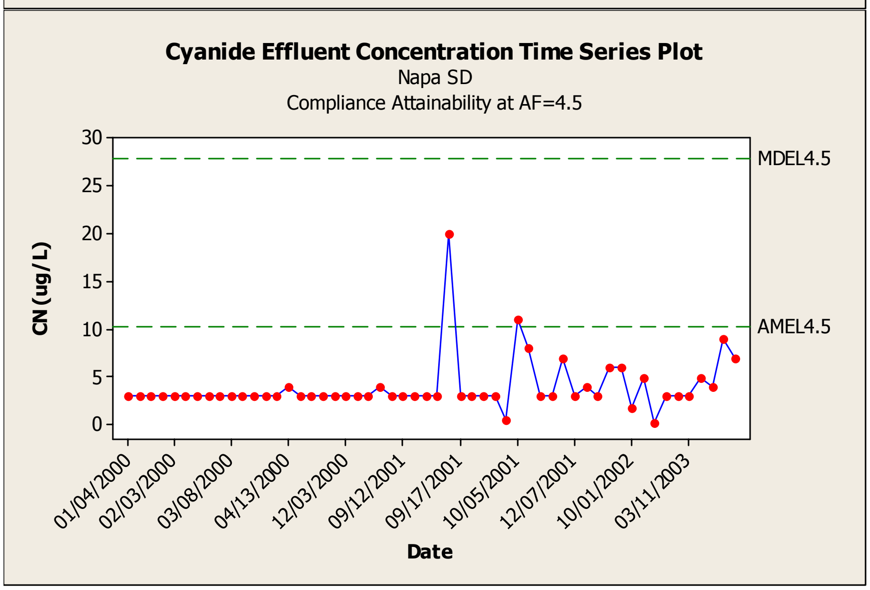
10/01/2002
03/11/2003
Date


Cyanide Effluent Concentration Time Series Plot
Napa SD
Compliance Attainability at AF=4.5
CN (ug/L)
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25
20
15
10
5
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MDEL4.5
AMEL4.5
01/04/2000
02/03/2000
03/08/2000
04/13/2000
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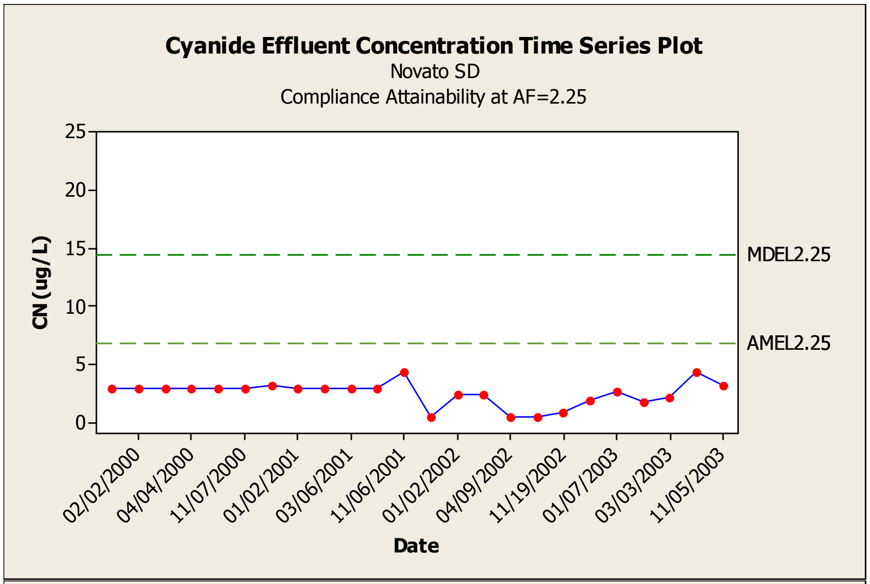
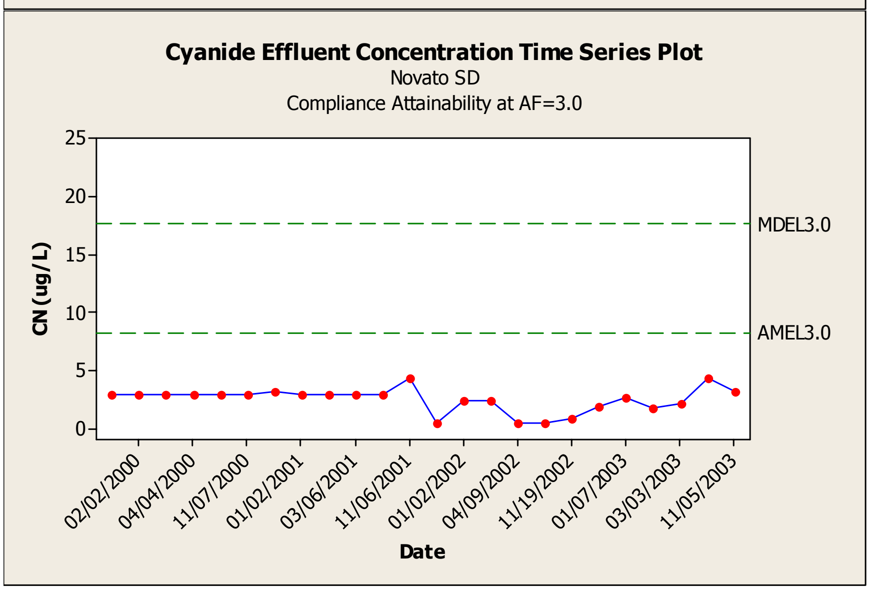
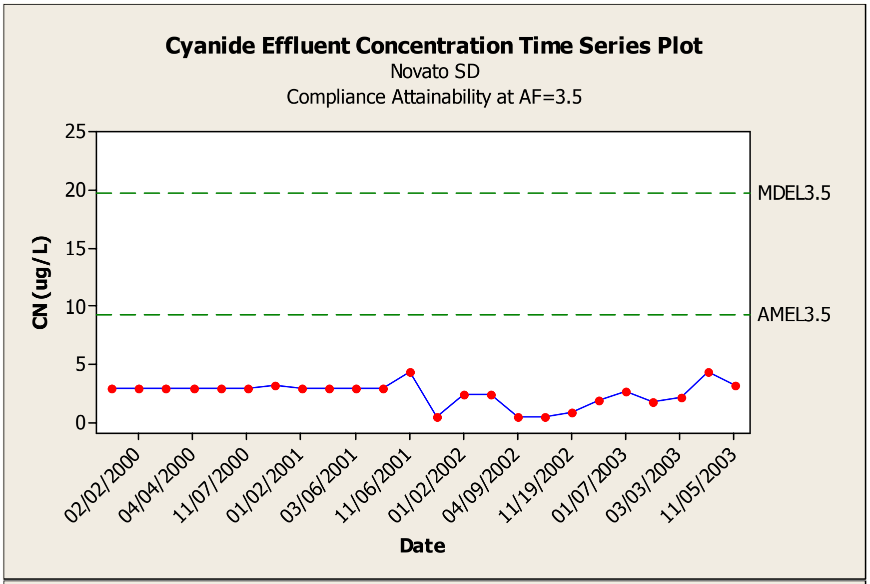
10/05/2001
12/07/2001
10/01/2002
03/11/2003
Date

8. Novato Sanitary District






Cyanide Effluent Concentration Time Series Plot
Novato SD
Compliance Attainability at AF=3.5
CN (ug/L)
25
20
15
10
5
0
MDEL3.5
AMEL3.5
02/02/2000
04/04/2000
11/07/2000
01/02/2001
03/06/2001
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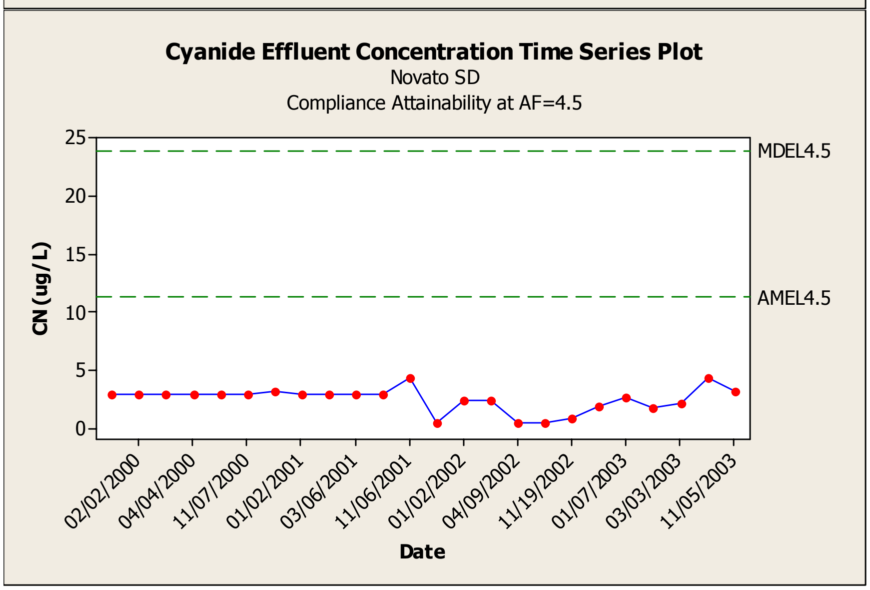
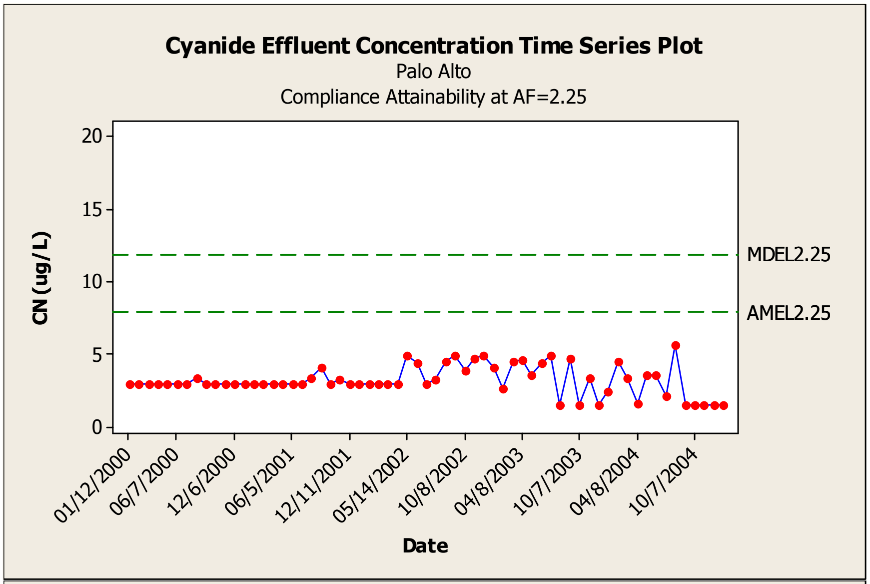
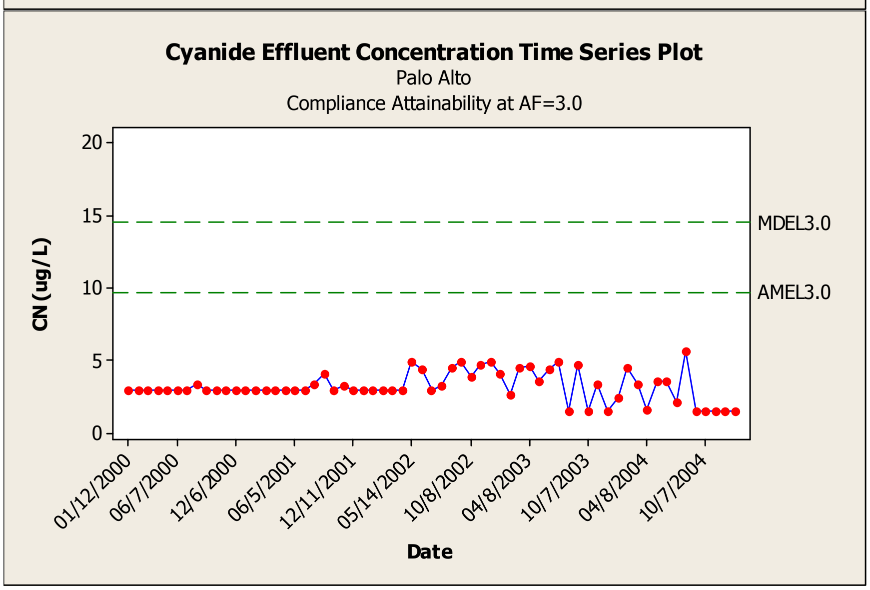
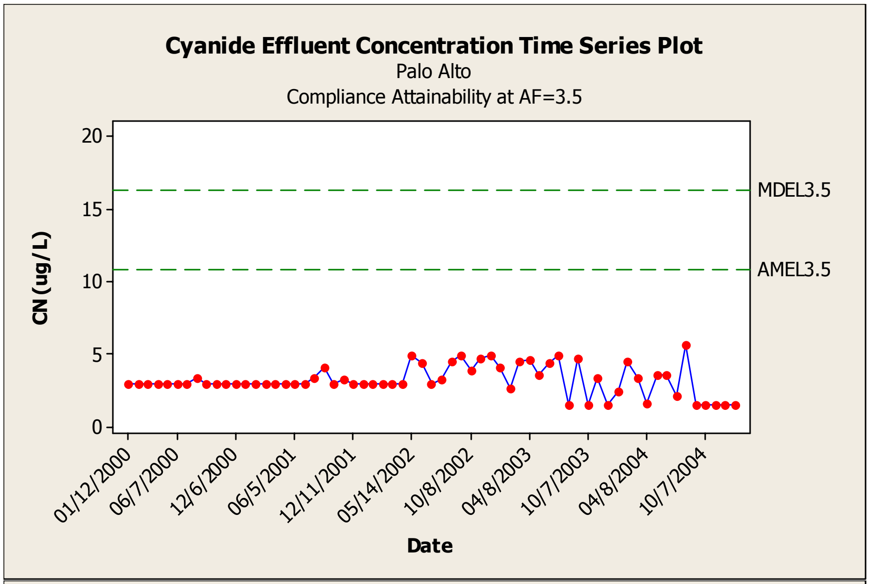
11/19/2002
01/07/2003
03/03/2003
11/05/2003
Date


Cyanide Effluent Concentration Time Series Plot
Novato SD
Compliance Attainability at AF=4.5
CN (ug/L)
25
20
15
10
5
0
MDEL4.5
AMEL4.5
02/02/2000
04/04/2000
11/07/2000
01/02/2001
03/06/2001
11/06/2001
01/02/2002
04/09/2002
11/19/2002
01/07/2003
03/03/2003
11/05/2003
Date

9. Palo Alto Regional Water Quality Control Plant






Cyanide Effluent Concentration Time Series Plot
Palo Alto
Compliance Attainability at AF=3.5
CN (ug/L)
MDEL3.5
AMEL3.5
0
5
10
15
20
01/12/2000
06/7/2000
12/6/2000
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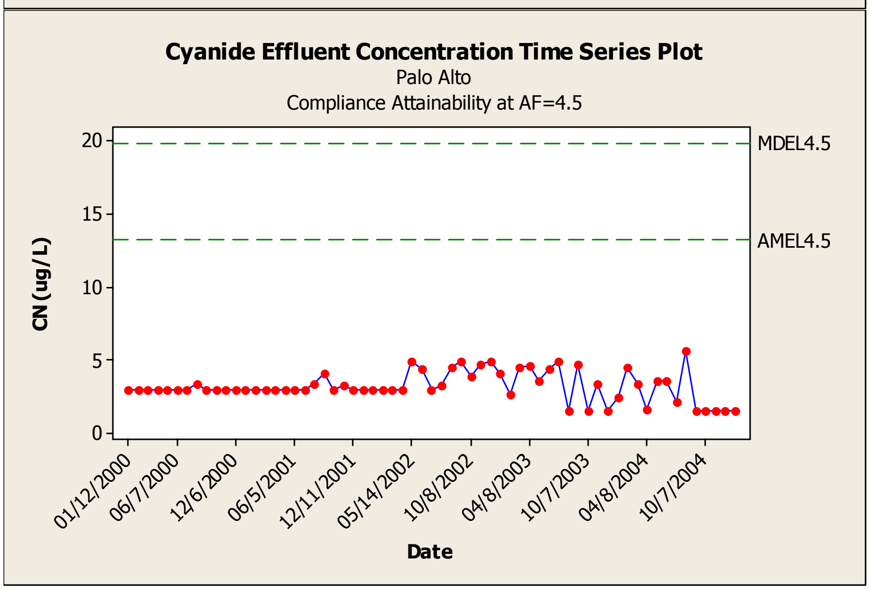
04/8/2003
10/7/2003
04/8/2004
10/7/2004
Date


Cyanide Effluent Concentration Time Series Plot
Palo Alto
Compliance Attainability at AF=4.5
CN (ug/L)
MDEL4.5
AMEL4.5
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5
10
15
20
01/12/2000
06/7/2000
12/6/2000
06/5/2001
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04/8/2003
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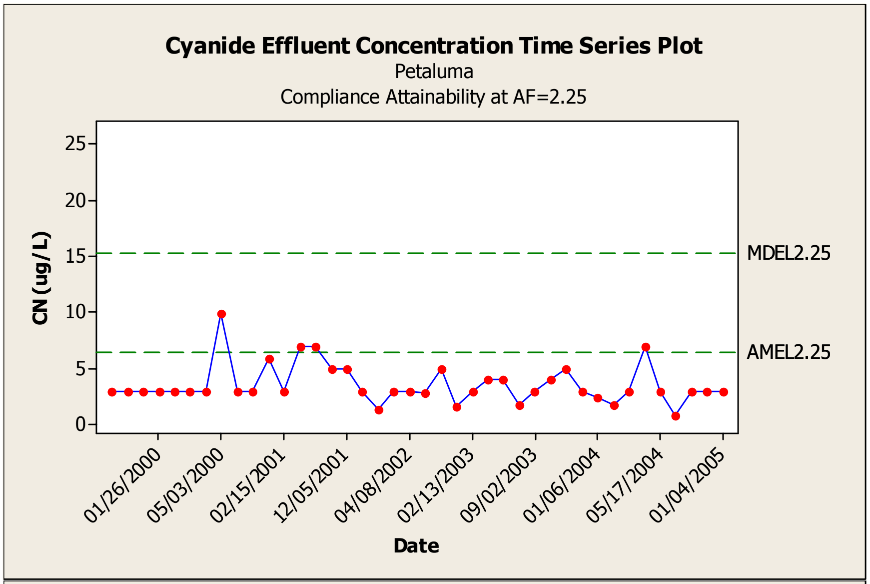
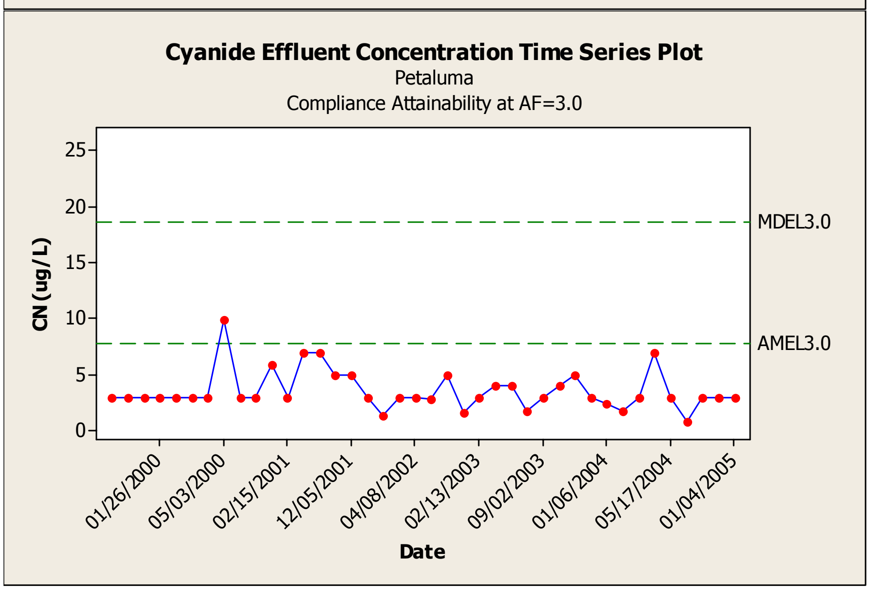
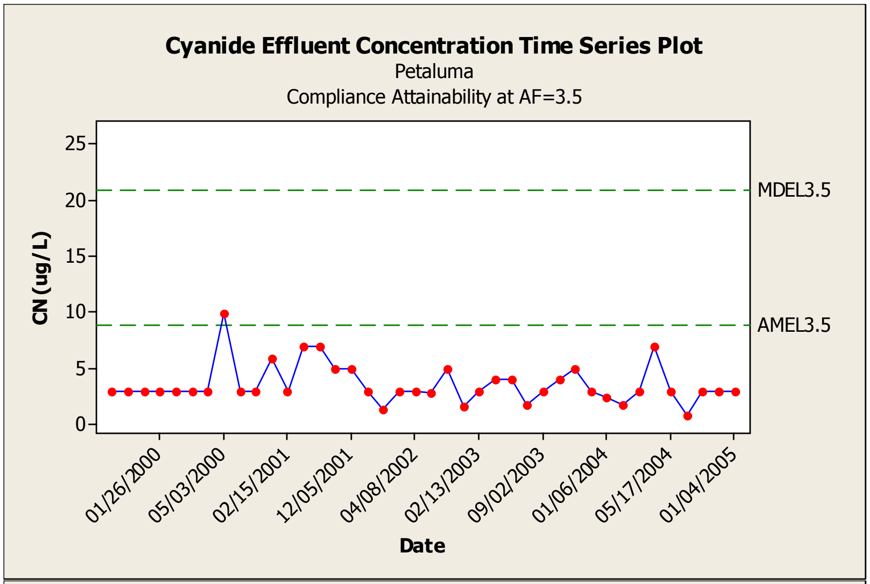
04/8/2004
10/7/2004
Date

10. City of Petaluma






Cyanide Effluent Concentration Time Series Plot
Petaluma
Compliance Attainability at AF=3.5
CN (ug/L)
MDEL3.5
AMEL3.5
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5
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15
20
25
01/26/2000
05/03/2000
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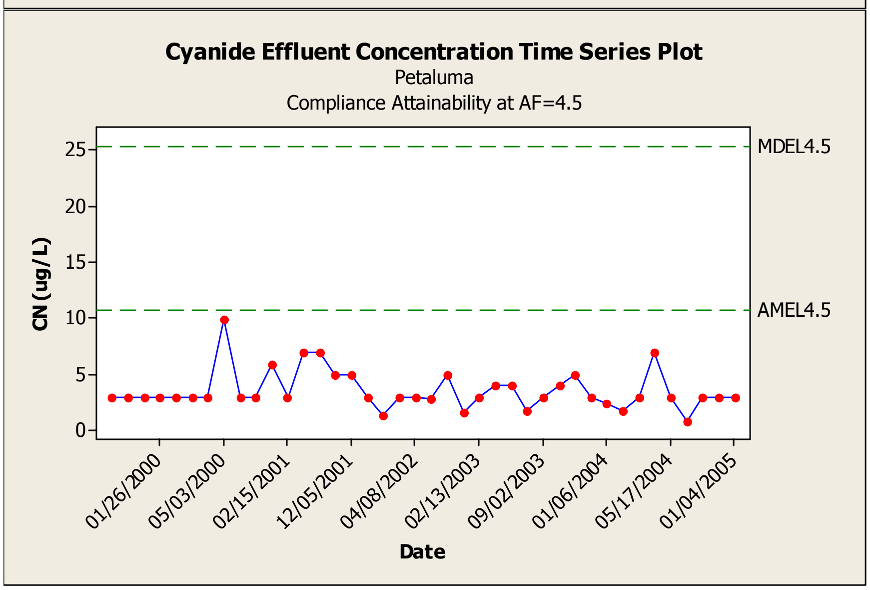
01/06/2004
05/17/2004
01/04/2005
Date


Cyanide Effluent Concentration Time Series Plot
Petaluma
Compliance Attainability at AF=4.5
CN (ug/L)
MDEL4.5
AMEL4.5
0
5
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15
20
25
01/26/2000
05/03/2000
02/15/2001
12/05/2001
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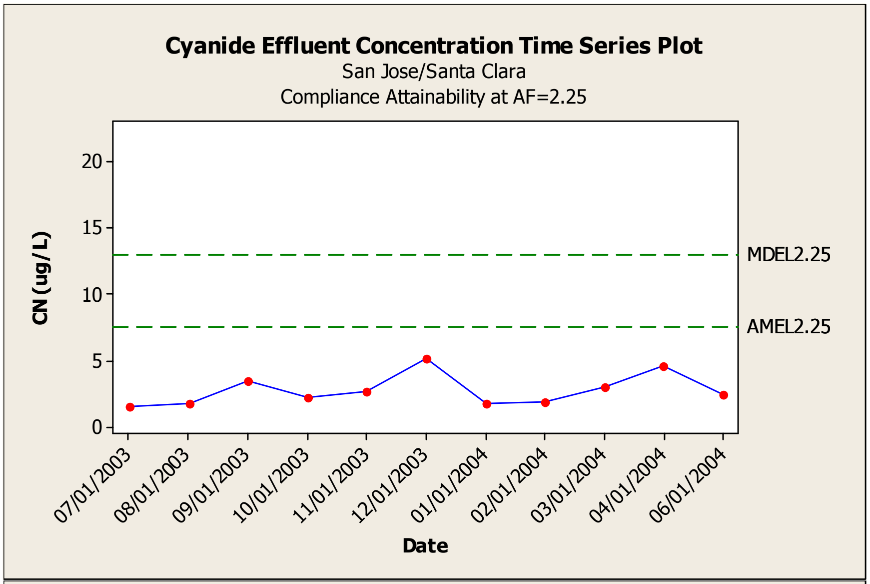
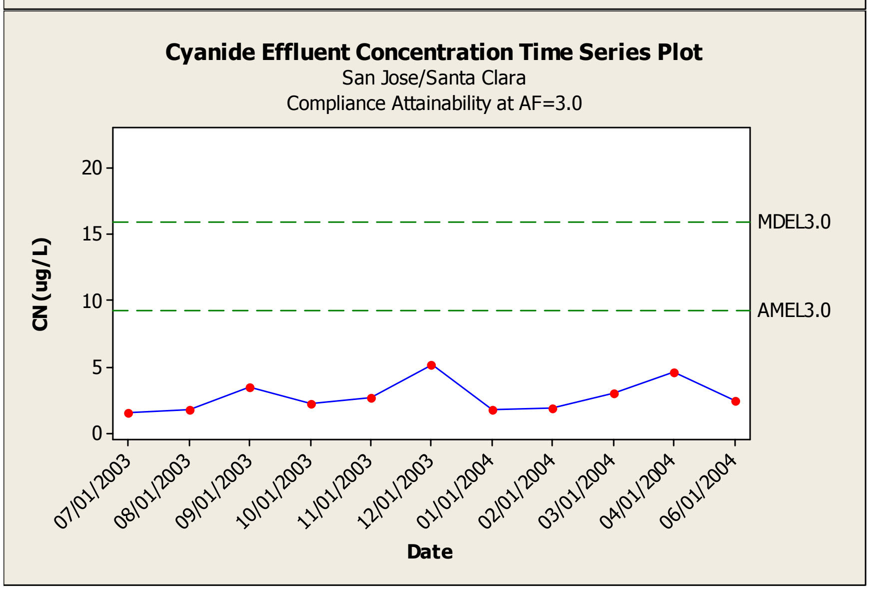
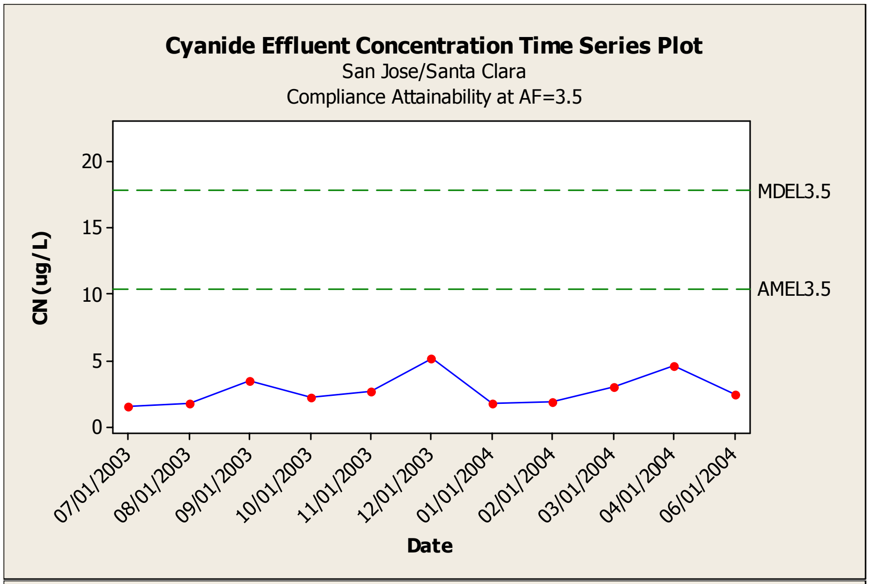
09/02/2003
01/06/2004
05/17/2004
01/04/2005
Date

11. San Jose/Santa Clara






Cyanide Effluent Concentration Time Series Plot
San Jose/Santa Clara
Compliance Attainability at AF=3.5
CN (ug/L)
MDEL3.5
AMEL3.5
0
5
10
15
20
07/01/2003
08/01/2003
09/01/2003
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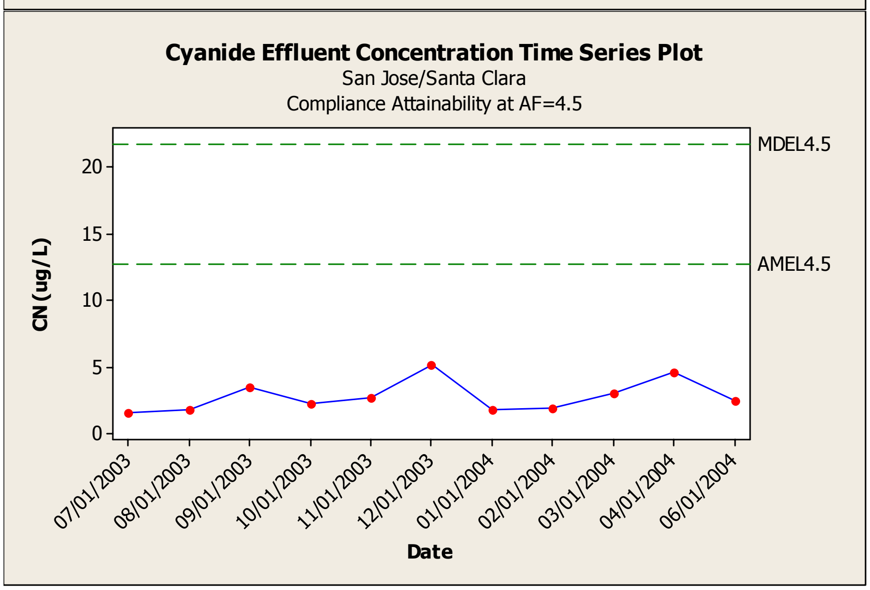
02/01/2004
03/01/2004
04/01/2004
06/01/2004
Date


Cyanide Effluent Concentration Time Series Plot
San Jose/Santa Clara
Compliance Attainability at AF=4.5
CN (ug/L)
MDEL4.5
AMEL4.5
0
5
10
15
20
07/01/2003
08/01/2003
09/01/2003
10/01/2003
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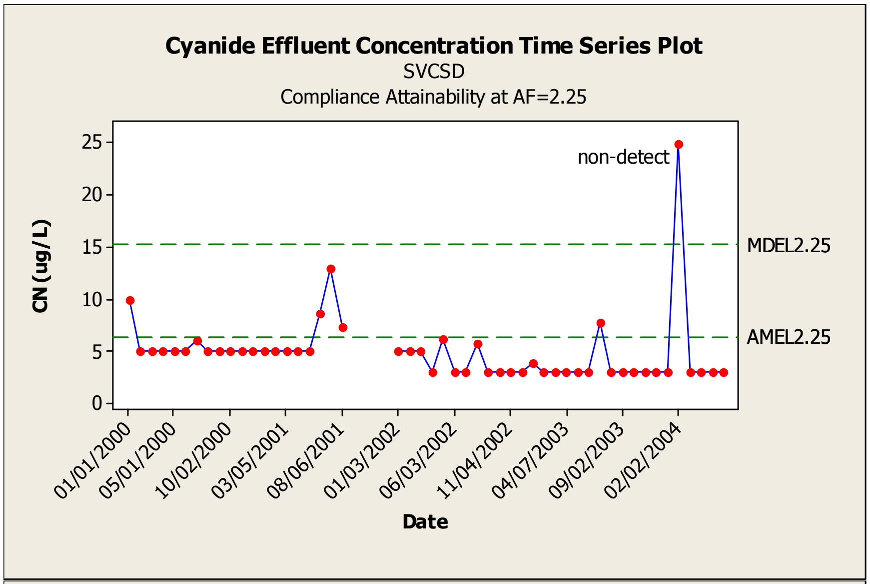
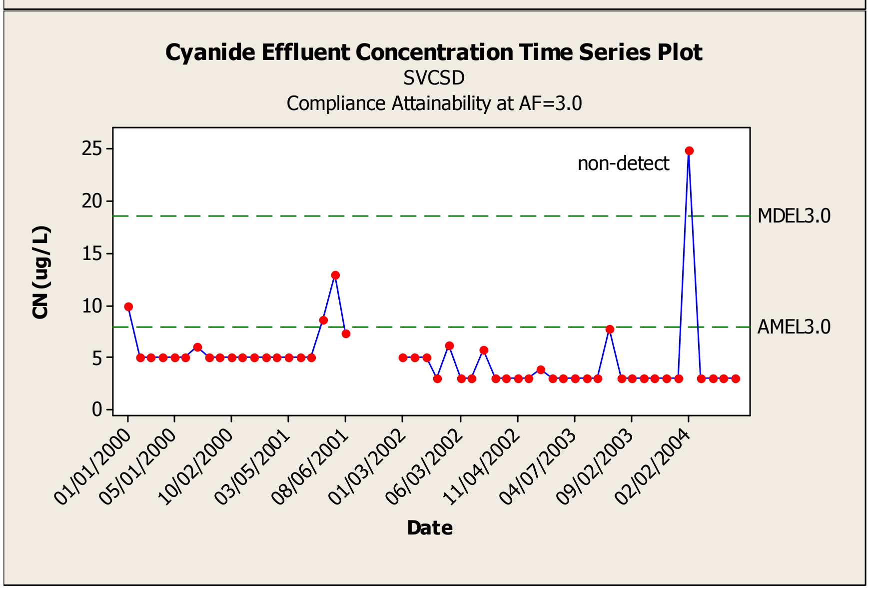
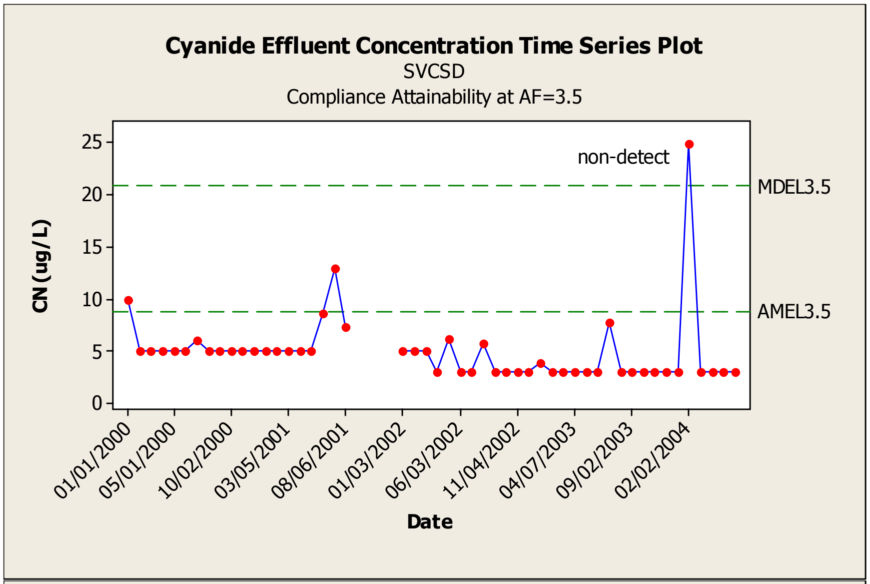
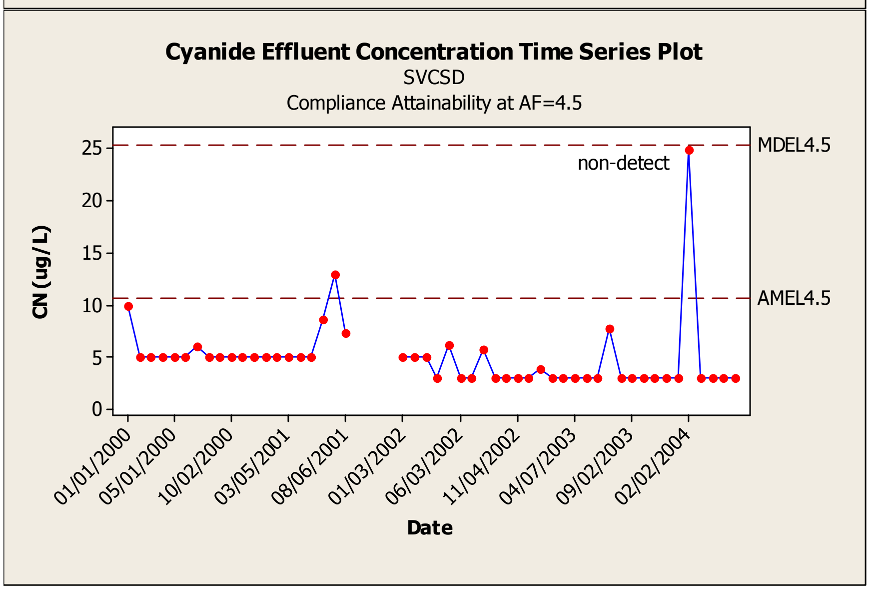
01/01/2004
02/01/2004
03/01/2004
04/01/2004
06/01/2004
Date

12. Sonoma Valley County Sanitation District






Cyanide Effluent Concentration Time Series Plot
SVCSD
Compliance Attainability at AF=3.5
CN (ug/L)
25
20
15
10
5
0
non-detect
MDEL3.5
AMEL3.5
01/01/2000
05/01/2000
10/02/2000
03/05/2001
08/06/2001
01/03/2002
06/03/2002
11/04/2002
04/07/2003
09/02/2003
02/02/2004
Date


Cyanide Effluent Concentration Time Series Plot
SVCSD
Compliance Attainability at AF=4.5
CN (ug/L)
25
20
15
10
5
0
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MDEL4.5
AMEL4.5
01/01/2000
05/01/2000
10/02/2000
03/05/2001
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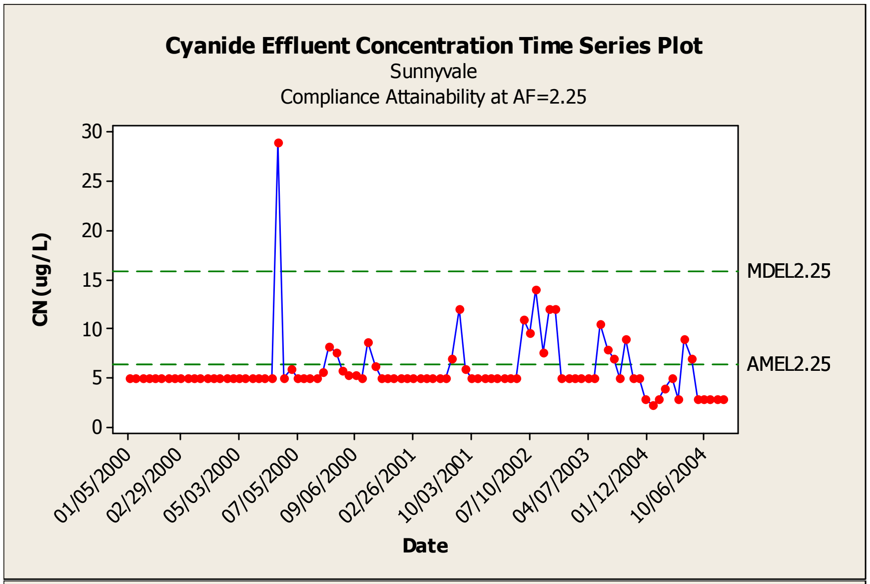
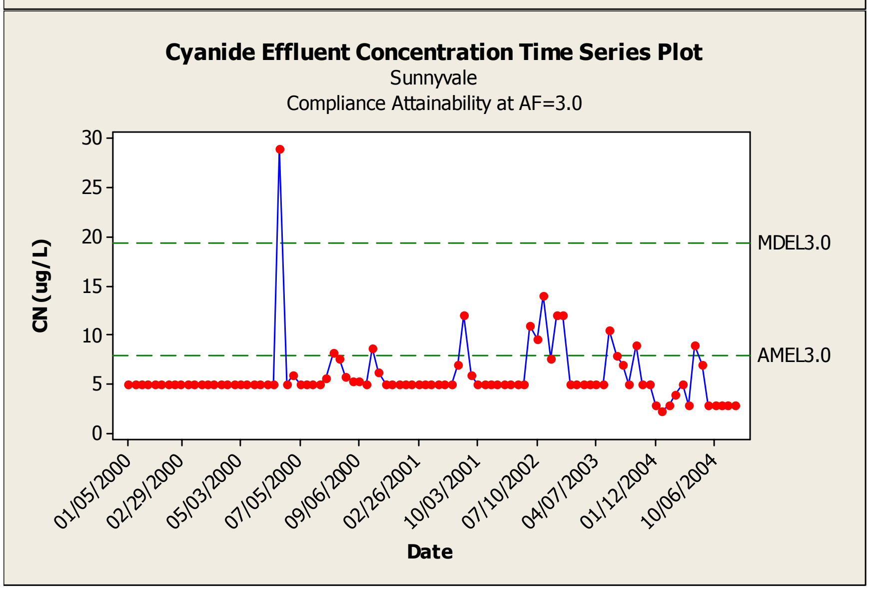
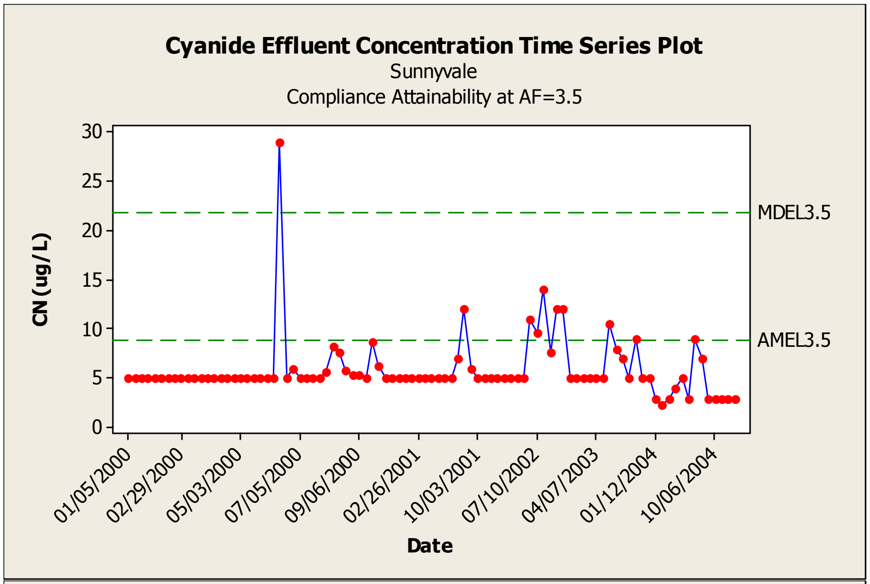
01/03/2002
06/03/2002
11/04/2002
04/07/2003
09/02/2003
02/02/2004
Date

13. City of Sunnyvale






Cyanide Effluent Concentration Time Series Plot
Sunnyvale
Compliance Attainability at AF=3.5
CN (ug/L)
Date
MDEL3.5
AMEL3.5
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15
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01/05/2000
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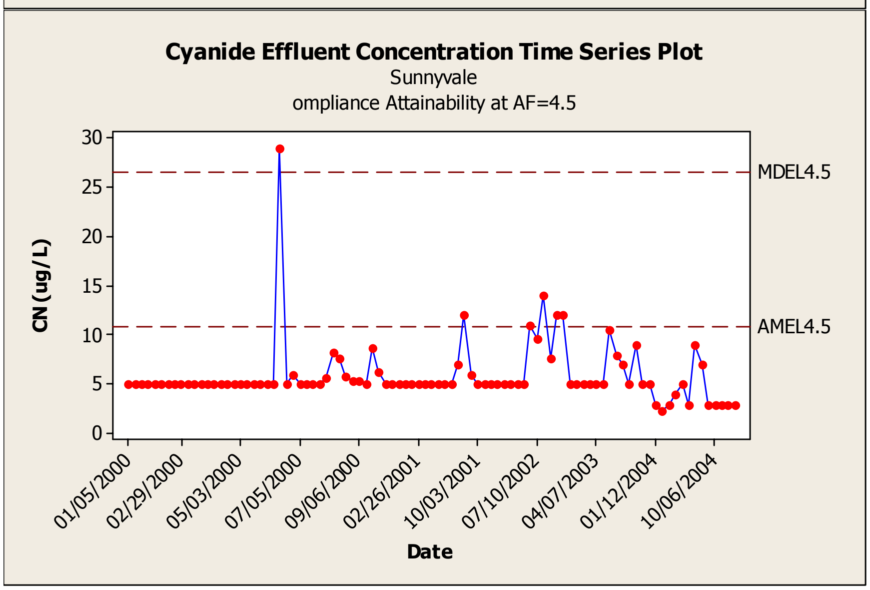
01/12/2004
10/06/2004


Cyanide Effluent Concentration Time Series Plot
Sunnyvale
ompliance Attainability at AF=4.5
CN (ug/L)
Date
MDEL4.5
AMEL4.5
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5
10
15
20
25
30
01/05/2000
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05/03/2000
07/05/2000
09/06/2000
02/26/2001
10/03/2001
07/10/2002
04/07/2003
01/12/2004
10/06/2004

Appendix G

Peer Review Comments and Responses to Comments

Review of
Technical Basis for Updated Cyanide Objectives for the San Francisco Bay Region

David Sedlak

Water Board Staff Responses Indicated in Bold Arial Text

The document explains proposed changes to the basin plan for the San Francisco Bay in response to concerns about the presence of cyanide in point source discharges. Site-specific standards are developed for cyanide by including new data on the toxicity of cyanide to four species of crab native to the west coast of the United States and attenuation factors for cyanide in shallow water discharges. The document describes the technical approach, the potential implications for aquatic species and alternatives considered in the analysis. The recommendations will result in a relaxation of the current standards and will require additional monitoring in San Francisco Bay to assure that cyanide concentrations fall within the acceptable range.

1. The site-specific criteria for cyanide were developed by substituting acute toxicity data for four species of crabs not originally included in the cyanide water quality criterion document for the Eastern rock crab. The recalculated values increase because the new crab species are less sensitive to cyanide than the Eastern rock crab. The approach used to recalculate the criteria has undergone peer review by one of the top scientific journals in the field of ecotoxicology (i.e., *Environmental Toxicology and Chemistry*) and has been adopted by the State of Washington for Puget Sound. I was unable to find other scientific papers that indicated significant disagreement with this approach. I am not an expert in the field of ecotoxicology and cannot comment on the details of the toxicology studies. However, the fact that the paper has undergone peer review and review by the State of Washington and that other scientists have not expressed contrary opinions suggests that the site-specific criteria are reasonable for San Francisco Bay.

Response: Comment noted. The proposed site-specific objective appears scientifically sound.

2. The document also describes the use of attenuation factors for cyanide in San Francisco Bay. The approach employs data on cyanide concentrations measured near the discharge points of wastewater treatment plants to account for the effects of dilution and transformation on cyanide concentrations. While I believe that the approach of using attenuation factors may have merit in this situation, I found the documentation of the attenuation factors included in the report to be inadequate. The explanation of the data and methods used for arriving at the specific values to be employed was unclear and the documentation needed to assess the quality of the science used to arrive at the values was not included in the report or the appendix. I spent a considerable amount of time trying to understand the data and believe that members of the public trying to understand the document would not be able to evaluate the document from the information provided in the draft report. For example, the report indicates that the attenuation factors used in the analysis were based on data from Artesian Slough and Coyote Creek as reported by the City of San Jose (p. 114 and 115). The data provided indicate a median concentration of 2.5 mg/L in the outfall, which increases to 3.3 mg/L before falling to 1.1 mg/L and 0.5 mg/L within 8.5 km. The report listed attenuation factors of 2.25 and 4.5 for these two observations, respectively. Using the formula included in the report, I obtained attenuation factors of 2.27 and 5.0 for these two observations. There is no explanation of why the concentrations increased between the outfall and the first two observation points (experimental

error? artifacts in the analytical method? Seasonal variation in flows?) nor are any of the sampling methods described (are these grab samples? 24-hour composites?).

The main scientific justification for using attenuation factors in lieu of dilution is that cyanide degrades in surface waters. The information provided in Appendix D cannot be used to assess the validity of this supposition because there has not been an attempt to discriminate between dilution and attenuation. Without some data to indicate that the concentrations decrease through some factor other than dilution, the attenuation factors seem like an alternative way of estimating dilution from empirical data. I doubt that the SFRWQCB would use this approach for a compound that is known not to degrade in surface waters. Therefore, it seems like the report needs to address the issue of degradation more directly.

I presume that somewhere there is a report that provides more detail on the data included in Appendix D. I believe that this report would be strengthened considerably if such information were included in the appendix or in the main body of the report. In particular, I would like to see more information on the data used to generate attenuation factors in appendix D, the sampling program design and results (e.g., methods, sample types, actual data and not medians), the expected dilution at each sampling site based on hydrologic modeling and tracer studies, interpretation of uncertainty in data and estimated attenuation factors.

Response: We have made significant changes to better explain the scientific basis of the attenuation factor analysis. An appendix to the report is added, Appendix L, that provides rationale used to derive the information in Appendix D. It also distinguishes dilution from degradation along the gradient away from the San Jose/Santa Clara discharge point, which formed the basis for attenuation factors that were confirmed by other shallow water discharger monitoring and modeling studies. Appendices B and D have been updated to include the raw data (n=225 for San Jose and other shallow water dischargers) used to arrive at the attenuation factor. Methods and sample types are also included as Appendix M for the methodology developed by the City of San Jose. Appendix N is added which evaluates the biological community along an arguably worst-case shallow water discharger gradient and suggests no adverse biological effects.

Appendix L contains the following explanation for why higher concentrations of cyanide were observed in the receiving waters than in the effluent on the same day. The final effluent sample is taken at the head of the effluent discharge channel; SB15 is located 790 meters downstream at the overflow weir from the discharge channel. In most instances, these samples were taken on the same day in the same 40 minute time period. Therefore, differences in concentration between these two whole effluent samples (which are essentially field duplicates) are attributable to analytical variability and short-term minor variability in effluent quality. In instances where samples were taken one day apart, apparent increases in cyanide concentration at downstream locations were likely the result of day-to-day variations in effluent cyanide concentrations in addition to analytical and short-term variability. For the period November 2003 to June 2004 when samples were collected at all three locations, the median cyanide concentrations were 2.9 ug/l in final effluent, 3.0 ug/l at SB15 and 2.5 ug/l at SB14. In the calculation of attenuation factor values, final effluent concentrations (rather than the slightly higher SB15 concentrations) were used.

Specific comments on the report and suggestions for improvements are listed below:

3. Page 1-5, second sentence: "…are typically undetected at concentrations far below levels…" This sentence is confusing. I think the authors mean that cyanide is not detected even using methods with detection limits below levels that cause toxicity to marine organisms. Can the sentence be reworded?

Response: The confusing statement is not necessary to the report, and has been deleted.

4. Page 1-5: Page 3-12: second sentence. At pH 8.5 HCN accounts for about 90% of the free cyanide. This sentence implies all of the free cyanide is protonated rather than most of the free cyanide.

Response: The sentence was corrected.

5. Page 1-5, last paragraph: Thiocyanate has a negative charge (SCN^-).

Response: Corrected.

6. Page 3-14: Table 2: AMEL and MDEL are never defined. Also, it would be easier if there were a page break and the whole table was placed on one page.

Response: Problem addressed.

7. Page 3-22: What is "organically complexed cyanide"? How does an anion form a complex with an organic compound?

Response: This incorrect statement has been deleted.

8. Page 4-37; fourth full paragraph: "disinfectants" is missing an s.

Response: Corrected.

9. Discussion on impacts of chlorination and UV disinfection starting on page 4-38: The discussion on these pages appears to have implications for wastewater disinfection that are not addressed in the report. For example, the authors state that increasing the chlorine dose would have a benefit of destroying cyanide. What are the implications for a utility that decreased their chlorine dose (e.g., if the treatment plant used a small dose of chlorine to prevent fouling of filters but used UV for final disinfection)? Also, the report indicates that UV light can form significant amounts of cyanide. I think that it is important to mention that the UV conditions used in the referenced study were not necessarily intended to mimic those employed for wastewater disinfection and that the potential for cyanide formation during effluent disinfection is unknown.

Response: We reviewed this and agree that the author of the UV reference (Zheng et al. 2004a) does not explicitly state whether the conditions used in the study *were*, or *were not* modeled from wastewater treatment processes. We have edited the report to more accurately portray the potential contribution of UV to cyanide formation, and have conducted an economic analysis in Section 10.3 regarding the switching of chlorination processes to UV processes for the region's POTWs, concluding that the costs and uncertainty of treatability outweigh the benefits of converting to UV radiation at this time.

Also, the report cites the WERF report to justify some of the conclusions. WERF reports are often not readily accessible to the public. I suggest that you also include the relevant citations to the peer-reviewed literature (as you have already done in many places).

Response: As suggested, references to the WERF report that point to information derived from a previous study have been changed to reference those specific studies.

10. Page 4-40: There is a statement about ozone forming cyanide from thiocyanate. Either include a reference or delete the statement.

Response: Statement deleted.

11. Page 5-42: In the third full paragraph there is a statement about the absence of cyanide in urban runoff. Please include a citation.

Response: In the Water Board's urban runoff monitoring experience, cyanide has not been detected in any sample in streets or in creeks. We do not believe a specific reference is necessary to assert this observation, which is based on collective experience of Water Board staff review of numerous technical reports.

12. Page 5-44: The report states, "The 3.5 attenuation factor would establish more protective limits than the 4.5 attenuation factor while still providing POTWs with attainable effluent limits… For these reasons, 3.5 is the recommended attenuation factor…" This sounds as if the RWQCB is setting the attenuation factor to assure that the treatment plants don't have to do anything to comply with the site-specific standard. I was under the impression that the attenuation factor was supposed to be set to protect the environment and not to assure compliance of the regulated discharges.

Response: Available environmental information suggests that the status quo is protective of water quality (now better explained in Appendix N and Section 7.3). This statement from the report reflects the careful analysis Water Board staff have completed to balance attainability and protection of the environment. The Basin Plan and SIP require mixing zones to be as "small as practicable." The practicability is determined by iteratively analyzing ability of the 12 shallow water dischargers to comply with effluent limits based on stepwise attenuation factors. The point at which the same few dischargers may have compliance issues was determined (4.5 vs. 3.5) and therefore 3.5 was selected as a protective policy measure. As shown in Appendix F, at 3.0, more dischargers would have attainability issues, so 3.5 is a reasonable cutoff point. The enforceable effluent limits, Cyanide Action Plan and model permit provision ensure that the treatment plants will have to do something to comply with the site-specific objective, so we respectfully disagree with this observation.

13. Table 15 seems to have some interesting information in it. It could use more explanation.

Response: This table includes the calculation of the proposed site-specific objective in detail, according to U.S. EPA methodology. We made sure that it is appropriately referenced in the text. We do not believe any more explanation is necessary, as it can be compared with calculations of existing objectives in Tables 11 and 12 to see differences.

Appendix H

Notice of Filing

Appendix I

Environmental Checklist Form

Appendix J

Draft Model Permit Language for Municipal Dischargers

DRAFT MODEL NPDES PERMIT PROVISION FOR MUNICIPAL DISCHARGERS SAN FRANCISCO BAY REGION

4. **Regional Cyanide Action Plan**

As part of the implementation of the marine cyanide site-specific objective, the discharger shall implement appropriate pretreatment, source control and pollution prevention for cyanide. The discharger shall consider reductions in effluent concentration achieved through source control; and economically feasible optimization of treatment plant processes, if new information on cyanide minimization in disinfection processes becomes available. Identifying contributors of cyanide from the discharger's service area shall be in accordance with the following tasks and time schedule.

Task	Compliance Date
(1) Review and Update of Potential Cyanide Contributors	no later than 3 months after permit adoption

Submit an inventory of all potential contributors of cyanide to the treatment plant, acceptable to the Executive Officer, and proceed with Task 2, below. If no contributors of cyanide from the discharger's service area are identified, no further action is required during the life of this permit, unless the discharger receives a request to discharge detectable levels of cyanide to the sanitary sewer. In such an event the discharger will notify the Executive Officer and proceed with Task 2, below.

(2) Implement Cyanide Pollution Prevention Program	
Submittal of Final Report	1 year after Executive Officer's approval of Task 1

The discharger shall implement a local program aimed at the prevention of illicit discharges of cyanide to the sewer system. The local program shall consist, at a minimum, of the following elements:

a) Maintain list of potential contributors (e.g., metal plating operations, hazardous waste recycling, etc.).

b) Monitor total cyanide monthly in influents and effluents using low detection level cyanide analytical methods.

c) Within a year of permit adoption, perform a site inspection of each potential contributor to assess the need to include the facility in an ongoing program.

d) For facilities in the ongoing program or those covered by the pretreatment program, follow EPA Guidance such as *Industrial User Inspection and Sampling Manual for POTWs (EPA 831-B-94-01)* that provides inspection and wastewater sampling procedures such as:

- Perform routine inspections of facilities.
- Develop and distribute educational materials regarding the need to prevent illicit discharges to the sewer system.

e) Prepare an emergency monitoring and response plan to be implemented in the event that a significant cyanide discharge event occurs that causes an exceedance of effluent limits. The Plan should include procedures to verify the delivery, use and shipment of cyanide from a facility suspected of illicit discharges. (i.e. verify that State Hazardous Waste Manifests are consistent with the facility's permit application and self-monitoring report information and comparable to other disposal practices of similar local facilities).

f) Submit Final Report acceptable to the Executive Officer, documenting the above, within one year after approval of Task (1).

Appendix K

Basin Plan Assessment for Approval of Dilution Credit for Shallow Water Dischargers

The San Francisco Bay Region Water Quality Control Plan (Basin Plan) contains requirements that must be addressed as a condition of the award of a dilution credit to shallow water discharges. Since the proposed application of cyanide attenuation factors in the determination of effluent limits for shallow water dischargers provides, in part, for a consideration of dilution, the question has been raised whether these requirements have been addressed. Consideration of these Basin Plan requirements is described below. Basin Plan requirements are shown in *italics*.

The Basin Plan allows that a dilution credit may be granted for shallow water dischargers on a discharger-by-discharger and pollutant-by-pollutant basis.

For the proposed Basin Plan amendment and attenuation factor consideration, each shallow water discharger has been specifically evaluated. Additionally, the attenuation factor in the proposed Basin Plan applies only to cyanide, satisfying the pollutant-by-pollutant requirement.

The Basin Plan also stipulates that the Regional Board may "grant a dilution credit…if the discharger demonstrates that an aggressive requires a demonstration that aggressive pretreatment and source control program is in place, including the following:

- *Completion of a source identification study,*
- *Development and implementation of a source reduction plan, and*
- *Commitment of resources to fully implement the source control and reduction plan."*

As stated previously in this staff report, the cyanide measured in effluent is often a product of wastewater disinfection and is therefore often not amenable to source control by municipal agencies. This is evident through inspection of influent and effluent cyanide data for Bay area treatment facilities (see Table 4) and is well supported in the literature (Zheng et al, 2004; WERF, 2003).

A number of the shallow water dischargers (Palo Alto, San Jose, Novato Sanitary District, Sonoma County Water Agency) have performed source identification studies at municipal agencies in the Bay area. Industrial sources of cyanide (metal finishers and electroplaters) were identified in the Palo Alto and San Jose service areas and were controlled through the industrial pretreatment programs at these respective municipalities. No significant cyanide sources were identified in the studies performed by Novato and Sonoma County Water Agency.

The common understanding that the most significant cyanide source in many plants is the disinfection process obviates the need for individual cyanide source identification studies at each facility. In lieu of such advance studies, the proposed Basin Plan amendment requires that each Shallow Water Discharger perform an assessment of potential cyanide sources within its service area as an initial NPDES permit requirement. This will ensure that potentially significant cyanide sources are identified and will allow agencies to initiate illicit discharge prevention procedures for these sources. The NPDES permit will require the commitment of resources to fully implement the source control and illicit discharge plans in those agencies.

In addition to source identification and control, the Basin Plan requires that a demonstration be made that water quality objectives will be achieved, by ensuring the following:

A demonstration that the proposed effluent limitations will result in compliance with water quality objectives, including the narrative chronic toxicity objective, in the receiving water…

The water quality based effluent limits are derived to ensure that compliance with both acute and chronic chemical-specific water quality objectives will occur at the edge of the attenuation zone for each Shallow Water Discharger. Therefore, both numeric and narrative objectives will be attained in the receiving waters of the Bay outside of these attenuation zones. As described in Section 10.4.3, the expectation is that the concentration of cyanide in effluents is not expected to increase above existing levels. Ambient data indicates that existing concentrations of cyanide in the discharge gradients from shallow water dischargers are, in all cases, below the proposed acute cyanide saltwater objective of 9.4 ug/l and are typically below the proposed chronic objective of 2.9 ug/l. In addition, the proposed Cyanide Action Plan that will include cyanide as a pollutant of concern for all dischargers in their Pollutant Minimization Plans will bolster the identification and control of potentially significant illicit discharges in service areas where such sources exist, adding to the existing capability to control such discharges.

An evaluation of worst-case conditions (in terms of tidal cycle, currents, or instream flows, as appropriate) through monitoring and/or modeling to demonstrate that water quality objectives will continue to be met, taking into account the averaging period associated with each objective…

The monitoring and modeling performed for Shallow Water Dischargers provides empirical evidence (n=225) and/or predicted values to address steady state conditions along the discharge gradients. The modeling allows consideration of worst case conditions and consideration of appropriate averaging periods to ensure that water quality conditions will be met.

An evaluation of the effects of mass loading resulting from allowing higher concentrations of pollutants in the discharge, in particular, the potential for accumulation of pollutants in aquatic life or sediments to levels that would impair aquatic life or threaten human health.

As stated previously, cyanide degrades in the receiving water and does not accumulate in sediment or biota. Levels of cyanide in Shallow Water Discharger effluent do not approach levels of concern to human health (e.g., the OEHHA public health goal of 150 ug/l).

The Basin Plan also requires that the effluent limits resulting from a dilution credit must be consistent with anti-backsliding provisions of the Clean Water Act (CWA).

Anti-backsliding provisions apply in cases where final effluent limitations have been adopted in permits. For cyanide in the Bay area, no final cyanide limits exist in current NPDES permits. Therefore, the anti-backsliding provisions of the CWA do not apply in the case of cyanide. Additionally, none of the plants in question could comply with final limits derived from the proposed saltwater site-specific objectives for cyanide without consideration of attenuation. Therefore, anti-backsliding is not a constraint to the adoption of the proposed attenuation factor and effluent limits for shallow water dischargers.

Finally, the granting of dilution credit must be based on the provisions of the "Policy for Implementation of toxics Standards for Inland Surface Waters, Enclosed Bays and Estuaries of California (SIP)". These provisions include

The "RWQCB shall consider the presence of pollutants in the discharge that are carcinogenic, teratogenic, persistent, bioaccumulative, or attractive to aquatic organisms."

As stated in Section 3.3, cyanide is neither carcinogenic, teratogenic, persistent, nor bioaccumulative.

The "*RWQCB also shall consider…the level of flushing in water bodies such as…enclosed bays, estuaries…where pollutants may not be readily flushed through the system*."

The monitoring and modeling studies used in the consideration of attenuation factors and attenuation zones along the discharge gradients reflect consideration of the hydrodynamics and tidal flushing that occurs near Shallow Water Discharges. Because cyanide degrades, does not accumulate in the Bay, and does not pose an ambient concentration problem in the Bay, concern regarding flushing of cyanide from the Bay system is not warranted.

"*A mixing zone shall be as small as practicable."*

The attenuation zones have been determined to coincide with the point at which an attenuation factor of 3.5 is attained, determined to be the smallest practicable zone based on an evaluation of attainability (Appendix F). The resulting zones comprise a minor fraction of the surface area of the Bay and will not enable the existence of cyanide toxicity in the Bay.

Also, "…a mixing zone shall not:

(1) Compromise the integrity of the entire water body…

It is commonly recognized that cyanide is not currently compromising the integrity of the Bay or its uses. Ambient monitoring indicates that cyanide levels throughout the Bay proper are less than the detection limit of 0.4 ug/l, which is significantly less than the proposed cyanide site specific chronic objective of 2.9 ug/l. These ambient levels integrate the existing shallow water discharges of cyanide. As detailed in Section 10.4.3, the proposed consideration of attenuation factors in setting effluent limitations for Shallow Water Dischargers will not cause or contribute to increased cyanide concentrations in the Bay.

(2) cause acutely toxic conditions to aquatic life passing through the mixing zone…

The copepod *Acartia clausi*, the most acutely sensitive saltwater species, has an acute LC50 value of 30 ug/l in exposures to free cyanide; Rainbow trout, the most acutely sensitive freshwater species, has an acute LC50 value of 44 ug/l free cyanide. USEPA presumes that the "no effect" level for acute toxicity is typically one half of the LC50 value. Therefore, the approximate "no effect" levels for acute toxicity for *Acartia* and Rainbow trout are 15 ug/l and 22 ug/l free cyanide, respectively. Measured levels of total cyanide along the discharge gradients of Shallow Water Dischargers are less than 7 ug/L, typically less than 3 ug/L, and do not currently approach these concentration thresholds for acute toxicity. Total cyanide levels along the discharge gradients are not anticipated to increase under the proposed effluent limitations. Therefore, it is concluded that proposed effluent limitations will not result in acutely toxic conditions in Shallow Water Discharger attenuation zones.

(3) restrict the passage of aquatic life…

Cyanide concentrations in the vicinity of Shallow Water Dischargers will not interfere with the movement of aquatic species. The discharge locations are either dead-end sloughs or otherwise sited to avoid creation of migration barriers.

(4) adversely impact biologically sensitive or critical habitats…

Available toxicological information for cyanide indicates that sensitive aquatic species will not be impacted in the aquatic habitats in question.

(5) produce undesirable or nuisance aquatic life
(6) result in floating debris, oil or scum;
(7) produce objectionable color, odor, taste, or turbidity;
(8) cause objectionable bottom deposits;
(9) cause nuisance;

At the concentrations in question, cyanide is not known to produce undesirable aquatic life, floating debris, oil, scum, objectionable color, odor, taste turbidity, objectionable bottom deposits or nuisance conditions.

(10) dominate the receiving water body or overlap a mixing zone from different outfalls;

The attenuation zones described in Appendix L do not overlap.

(11) be allowed at or near any drinking water intake…"

No drinking water intakes are located in San Francisco Bay in the vicinity of the proposed Shallow Water Discharger attenuation zones.

In summary, to the extent the "attenuation zones" identified in the proposed Basin Plan amendment would be considered to be "mixing zones," it may be argued that the RWQCB must address the provisions of the Basin Plan and the SIP for approval of such zones. The above information indicates that those provisions would be satisfied, if deemed applicable.

Appendix L

Derivation of Attenuation Factors

The purpose of this appendix is to describe the methodology referenced in the staff report in the determination of the attenuation factors for Shallow Water Dischargers to San Francisco Bay. As stated in the staff report, a special study performed by the City of San Jose in 2003 and 2004 serves as the foundation for evaluation of the attenuation factor concept in the Bay. This study included the development of a data set of effluent and receiving water cyanide concentrations over a 12 month period (n=149) in Lower South San Francisco Bay. Sampling was performed along the discharge gradient from the San Jose/Santa Clara Water Pollution Control Plant in Artesian Slough and Coyote Creek. This appendix describes the methodology and results of that study. This appendix also summarizes the determination of attenuation factors and attenuation zones for other Shallow Water Dischargers to San Francisco Bay. Table 5, at the end of the appendix, contains summary statistics on the Shallow Water Discharger receiving water data collected for this proposed Basin Plan amendment.

This appendix contains the following sections:

- Definition of Attenuation
- San Jose Study Description
- San Jose Study Results
- Other Shallow Water Discharger Methods
- Other Shallow Water Discharger Results

<u>Definition of Attenuation</u>

Attenuation is defined to be the combination of dilution and degradation, where dilution is the mixing of treated effluent with Bay waters and degradation is the sum of all factors affecting the loss of cyanide in the environment, including volatilization, precipitation, sedimentation and microbial breakdown. The concept of an attenuation factor is considered to be a valid permitting approach for cyanide because cyanide is degradable and does not persist or accumulate in the aquatic environment. The City of San Jose study provides empirical and characteristic evidence of cyanide attenuation.

The formula for the determination of a cyanide "attenuation factor" (AF) value is as follows:

> AF = Effluent cyanide concentration / cyanide concentration at a selected location along a discharge gradient

Synoptic (or quasi-synoptic) sampling data for effluent and receiving waters serve as the basis for attenuation factor calculations. For some Shallow Water Dischargers, where sufficient ambient data is not available, dilution estimates from mathematical modeling studies were used to provide a conservative estimate (i.e. an underestimate) of cyanide attenuation.

San Jose Study Description

The City of San Jose performed a special Cyanide Attenuation Study in 2003 and 2004 to examine changes in cyanide concentrations that occur with distance downstream from the WPCP discharge point in Artesian Slough. The information below is taken from the final report for this study titled *Cyanide Attenuation Study, Watershed Protection Group, Environmental Services Department, City of San Jose, September 1, 2004*.

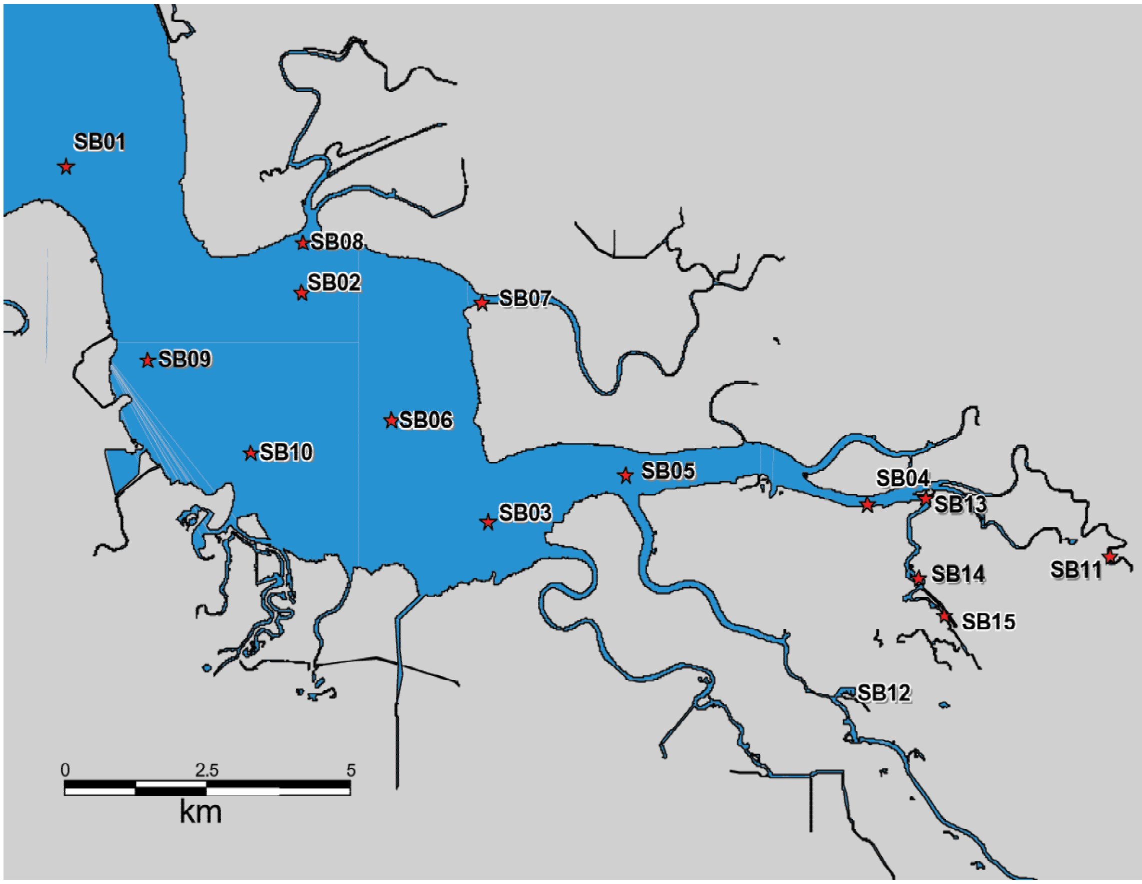
The purpose of the San Jose special study was two-fold: (1) to examine cyanide formation in the WPCP and (2) to determine empirical attenuation factors for cyanide along the WPCP discharge gradient in Artesian Slough and Coyote Creek in the southernmost area of Lower South Bay. The second purpose for the study (determination of empirical attenuation factors) is the focus of the following discussion.

For the special study, the City of San Jose developed and utilized low detection limit analytical methods for total cyanide determinations in effluent and in the receiving waters. The City performed various method enhancement studies to ensure the generation of high quality information in the special study. These included a Method Detection Limit study and studies of the effect of sample preservation and holding time on cyanide results.

The cyanide analytical methods used in this study were a modified version of methods 4500-CN B, C and E from Standard Methods, 20th Edition (APHA/AWWA/WEF 1998) (see description in Appendix M). Modifications of the methods were employed to lower the detection limits for measuring total cyanide. The modified procedure provided a Method Detection Limit of 0.06 ug/l and a Practical Quantitation Limit (PQL)(Reporting Limit) of 0.30 ug/l for Bay water. The Method Detection Limit for effluent samples was 0.2 ug/l, and the PQL (Reporting Limit) for effluent was 1.0 ug/l.

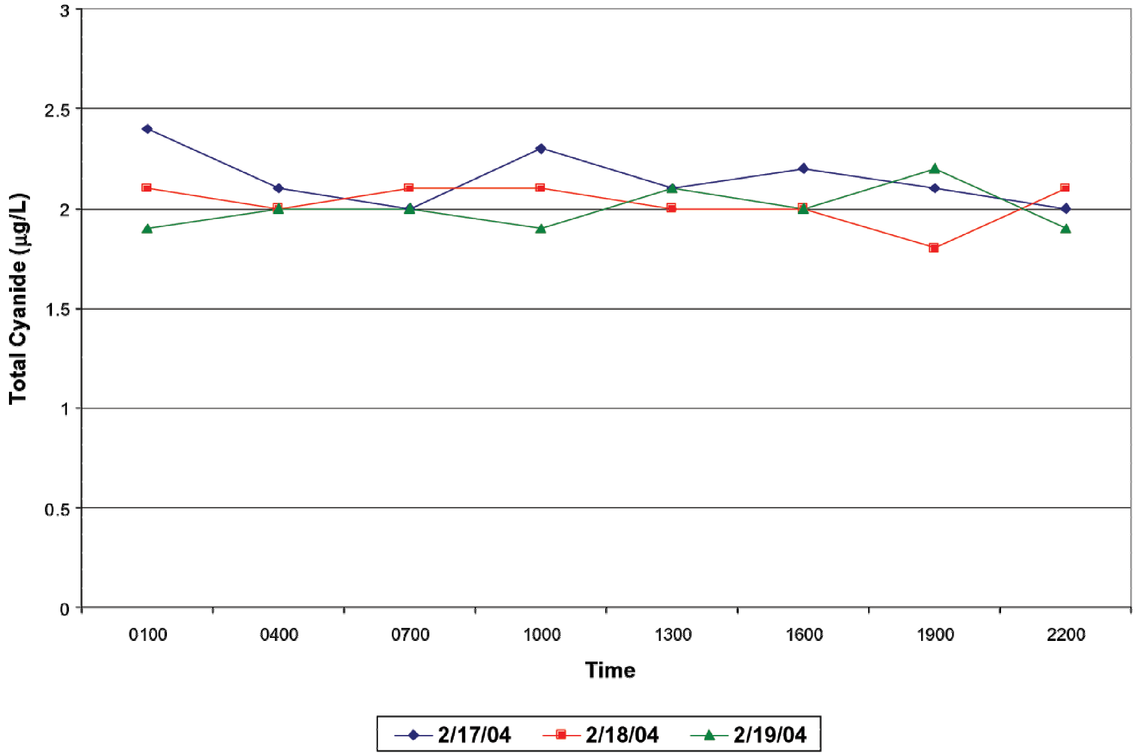
Discharge gradient sampling locations included plant effluent and 13 ambient downstream locations. The sampling locations are shown in Figure 1.

Figure 1. Sampling Locations for Empirical Cyanide Attenuation Study by San Jose/Santa Clara WPCP



The cyanide concentration values for effluent and ambient sampling locations used in the City of San Jose report were based on grab samples. Samples were obtained using a sample pumping system and apparatus as recommended in USEPA 1996 guidance for clean sampling techniques. The City studied the variability of effluent cyanide concentrations over a 72-hour period and found little variation in the daily means, maximums, minimums or standard deviations of the observed concentrations. The study involved 8 samples per day at three-hour time intervals (see Figure 2). Based on these results, the use of grab samples was deemed to be a representative sampling approach in effluent and in downstream waters affected by the effluent.

Figure 2. Variability of Effluent Cyanide Concentrations, San Jose/Santa Clara WPCP



The field sampling for each event was performed over a period of two days. Samples of effluent were typically taken during the field sampling period or the day before. Near-field ambient locations (SB15, SB14 and SB13) were typically collected over a one to 2 hour time period in each sampling event. Samples at other ambient locations were typically collected during the same 4 to 5 hour period (8AM to 1PM) each sampling day.

San Jose Study Results

The observed cyanide concentrations during the 12 month study (July 2003 to June 2004) are summarized in Table 1.

Table 1. Cyanide Attenuation Factor Calculations in South SF Bay
City of San Jose Cyanide Attenuation Study (2004)

	2003						2004					
Station	***July***	***Aug***	***Sep***	***Oct***	***Nov***	***Dec***	***Jan***	***Feb***	***Mar***	***Apr***	***May***	***Jun***
Final effluent	1.6	1.8	3.5	2.3	2.7	5.2	1.8	2	3.1	4.7	63	2.5
SB15 (Weir)	NS	NS	NS	NS	2.7	5.5	2	1.7	3.4	5.2	59	2.2
SB14 (Triangle)	NS	NS	2.7	3.1	2.3	3.8	2	1.6	2.8	4.2	27	2.3
SB13 (Mouth)	NS	NS	1.3	2.4	1.6	1.6	1.5	1.6	1.2	2.2	7.2	2.1
SB04	1	0.8	1.2	1.8	0.7	0.7	1.1	0.9	0.8	1.7	3.3	1.3
SB05	0.4	0.6	0.5	0.9	0.2	0.4	0.4	0.7	0.3	0.4	1.1	0.8
SB03	0.3	0.3	0.4	0.5	0.2	0.4	0.2	0.4	0.4	0.4	0.8	0.6
SB06	0.3	0.2	0.3	0.3	0.2	0.3	0.2	0.5	0.3	0.4	0.4	0.5
SB02	0.2	0.2	0.3	0.2	0.1	0.2	0.3	0.4	0.2	0.2	0.3	0.3
SB08	0.3	0.2	0.3	0.3	0.1	0.1	0.4	0.4	0.2	0.2	0.4	0.3
SB10	0.3	0.3	0.3	0.4	0.2	0.2	0.3	0.2	0.3	0.3	0.4	0.3
SB07	0.5	0.4	0.3	0.4	0.3	0.4	0.3	0.3	0.4	0.4	0.4	0.3
SB09	0.2	0.2	0.3	0.2	0.1	0.3	0.3	0.2	0.2	0.2	0.4	0.4
SB01	0.2	0.2	0.2	0.2	0.1	0.1	0.3	0.2	0.2	0.2	0.2	0.2
SB11	0.5	0.4	0.6	0.4	0.6	0.9	0.8	0.8	1.1	0.7	0.3	0.4
SB12	0.3	0.3	0.3	0.3	0.4	0.5	0.4	0.5	NS	0.5	0.4	0.3

Table 1 (cont.)

													Median AF Value
With May 04													
Final effluent	1.6	1.8	3.5	2.3	2.7	5.2	1.8	2	3.1	4.7	63	2.5	
SB04	1	0.8	1.2	1.8	0.7	0.7	1.1	0.9	0.8	1.7	3.3	1.3	
AF	1.60	2.25	2.92	1.28	3.86	7.43	1.64	2.22	3.88	2.76	19.09	1.92	2.51
Without May 04													
Final effluent	1.6	1.8	3.5	2.3	2.7	5.2	1.8	2	3.1	4.7		2.5	
SB04	1	0.8	1.2	1.8	0.7	0.7	1.1	0.9	0.8	1.7		1.3	
AF	1.60	2.25	2.92	1.28	3.86	7.43	1.64	2.22	3.88	2.76		1.92	**2.25**
With May 04													
Final effluent	1.6	1.8	3.5	2.3	2.7	5.2	1.8	2	3.1	4.7	63	2.5	
SB05	0.4	0.6	0.5	0.9	0.2	0.4	0.4	0.7	0.3	0.4	1.1	0.8	
AF	4.00	3.00	7.00	2.56	13.50	13.00	4.50	2.86	10.33	11.75	57.27	3.13	5.75
Without May 04													
Final effluent	1.6	1.8	3.5	2.3	2.7	5.2	1.8	2	3.1	4.7		2.5	
SB05	0.4	0.6	0.5	0.9	0.2	0.4	0.4	0.7	0.3	0.4		0.8	
AF	4.00	3.00	7.00	2.56	13.50	13.00	4.50	2.86	10.33	11.75		3.13	**4.5**
With May 04													
Final effluent	1.6	1.8	3.5	2.3	2.7	5.2	1.8	2	3.1	4.7	63	2.5	
SB13 (Mouth)	NS	NS	1.3	2.4	1.6	1.6	1.5	1.6	1.2	2.2	7.2	2.1	
AF			2.69	0.96	1.69	3.25	1.20	1.25	2.58	2.14	8.75	1.19	1.91

It should be noted that cyanide concentrations in individual samples taken at the first two stations downstream from the effluent discharge point in Artesian Slough (SB15 and SB14) were at times slightly higher than the final effluent cyanide concentrations. The explanation for these differences is as follows: The final effluent sample is taken at the head of the effluent discharge channel; SB15 is located 790 meters downstream at the overflow weir from the discharge channel. In most instances, these samples were taken on the same day in the same 40 minute time period. Therefore, differences in concentration between these two whole effluent samples (which are essentially field duplicates) are attributable to analytical variability and short-term minor variability in effluent quality. In instances where samples were taken one day apart, apparent increases in cyanide concentration at downstream locations were likely the result of day-to-day variations in effluent cyanide concentrations in addition to analytical and short-term variability. For the period November 2003 to June 2004 when samples were collected at all three locations, the median cyanide concentrations were 2.9 ug/l in final effluent, 3.0 ug/l at SB15 and 2.5 ug/l at SB14. In the calculation of attenuation factor values, final effluent concentrations (rather than the slightly higher SB15 concentrations) were used.

Attenuation factors were calculated for each monitoring event, using the above cyanide concentration data and the AF formula described above. The median attenuation factor values for stations SB04 and SB05 were 2.25 and 4.5, respectively. These values derived as follows:

- An attenuation factor value was calculated for each sampling event.

- The May 2004 event was excluded as an atypical event (excluding this event resulted in a more conservative, i.e. lower attenuation factor for each location)

- The median AF value at each location was determined from the data set of the individual AF values for each event.

Stations SB04 and SB05 were chosen as sites for the attenuation factor calculation based on the significant declines in cyanide concentrations observed at these locations.

Under typical discharge conditions along the discharge gradient, dilution appears to be an important factor affecting the observed cyanide attenuation values. This is seen through examination of the calculated attenuation factors at stations SB04 and SB05 in comparison to calculated dilutions derived from salinity measurements taken at the same time as the cyanide samples. The salinity data used in the calculation of dilution is shown in Table 2. The comparison of these dilution values with the median attenuation factor values is shown in Table 3.

Table 2. Dilution Calculations from San Jose Salinity Data
City of San Jose Cyanide Attenuation Study (2004)

Dilution at SB04 using Bay Salinity data at SB01													**Median Dilution Value**
Final effluent	0.6	0.6	0.6	0.6	0.6	0.5	0.6	0.6	0.6	0.6	0.6	0.6	
SB04	6.2	12.8	5.1	5.3	17.6	16.5	7.6	1.9	6.7	1.3	4	3.5	
SB01	25.1	27.2	27.2	28.9	28.2	28.2	23	17.6	16.7	19.1	24.4	26.7	
Percent effluent	0.77	0.54	0.83	0.83	0.38	0.42	0.69	0.92	0.62	0.96	0.86	0.89	
Dilution	1.30	1.85	1.20	1.20	2.60	2.37	1.45	1.08	1.61	1.04	1.17	1.13	**1.25**
Dilution at SB04 using Bay Salinity data at SB02													
Final effluent	0.6	0.6	0.6	0.6	0.6	0.5	0.6	0.6	0.6	0.6	0.6	0.6	
SB04	6.2	12.8	5.1	5.3	17.6	16.5	7.6	1.9	6.7	1.3	4	3.5	
SB02	24.7	26.7	27.7	26.6	26.2	27.7	22	12.2	16.5	18.5	22.8	24.9	
Percent effluent	0.77	0.53	0.83	0.82	0.34	0.41	0.67	0.89	0.62	0.96	0.85	0.88	
Dilution	1.30	1.88	1.20	1.22	2.98	2.43	1.49	1.13	1.62	1.04	1.18	1.14	**1.26**
Dilution at SB05 using Bay Salinity data at SB01													
Final effluent	0.6	0.6	0.6	0.6	0.6	0.5	0.6	0.6	0.6	0.6	0.6	0.6	
SB05	19.7	19.4	18.9	12.2	24	24.5	19.7	4.7	13.5	10.6	8.2	10	
SB01	25.1	27.2	27.2	28.9	28.2	28.2	23	17.6	16.7	19.1	24.4	26.7	
Percent effluent	0.22	0.29	0.31	0.59	0.15	0.13	0.15	0.76	0.20	0.46	0.68	0.64	
Dilution	4.54	3.41	3.20	1.69	6.57	7.49	6.79	1.32	5.03	2.18	1.47	1.56	**3.31**
Dilution at SB05 using Bay Salinity data at SB02													
Final effluent	0.6	0.6	0.6	0.6	0.6	0.5	0.6	0.6	0.6	0.6	0.6	0.6	
SB05	19.7	19.4	18.9	12.2	24	24.5	19.7	4.7	13.5	10.6	8.2	10	
SB02	24.7	26.7	27.7	26.6	26.2	27.7	22	12.2	16.5	18.5	22.8	24.9	
Percent effluent	0.21	0.28	0.32	0.55	0.09	0.12	0.11	0.65	0.19	0.44	0.66	0.61	
Dilution	4.82	3.58	3.08	1.81	11.64	8.50	9.30	1.55	5.30	2.27	1.52	1.63	**3.33**

Table 3. Effect of dilution on Attenuation Factors at Stations SB04 and SB05

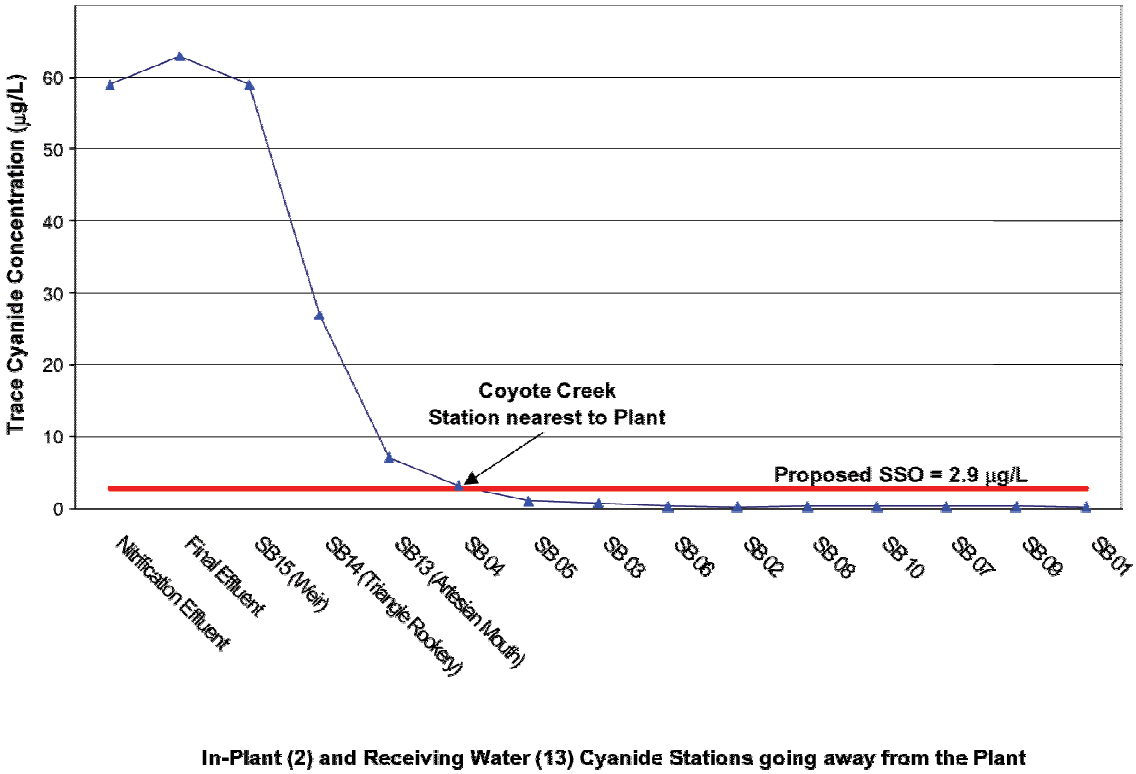
Station	***Attenuation Factor (median)***	***Calculated Dilution (median)***
SB04	2.25	1.25
SB05	4.5	3.3

As shown in Table 3, the median attenuation factor at SB04 is 2.25, while the median dilution at SB04 based on salinity measurements and subsequent calculations of effluent percentages is 1.25. At SB05, the median attenuation factor is 4.5, while the calculated dilution ratio is 3.3.

This finding is also supported qualitatively by historical dilution study results. Calculated AF values were 2.25 and 4.5 at SB04 and SB05, respectively. In a dilution study performed in 1990, the predicted dilutions at SB04 and SB05 was determined to be 2.1 and 4.5.

A period of rapid degradation of cyanide was observed during the extraordinary May 26, 2004 sampling event by the City of San Jose (see Figure 3). In the May 2004 event, an illicit cyanide discharge to the WPCP produced an extremely elevated effluent concentration of 63 ug/l. Measurements along the discharge gradient at SB13, SB04 and SB05 indicated cyanide concentrations of 27 ug/l, 7.2 ug/l, 3.3 ug/l and 1.1 ug/l. The associated attenuation factors at these sites were 8.8, 19.1 and 57, respectively. These values demonstrate significant, rapid degradation of the elevated cyanide concentrations that far outweighed the effect of dilution. This May observation demonstrates that degradation would be anticipated to exert a greater influence along the discharge gradient at higher effluent cyanide concentrations.

Figure 3 – High Cyanide Effluent Discharge and Receiving Water Gradient, San Jose/Santa Clara WPCP, May 26, 2004



The degradation of cyanide is also evident in the examination of ambient data in Table 1 for the far field Bay stations (SB02, SB06, SB07, SB08, SB09 and SB10) where concentrations were typically less than or equal to 0.4 ug/l and SB01, near the Dumbarton Bridge, where cyanide concentrations were always less than 0.3 ug/l. These observations are supported by RMP data that indicate cyanide levels below detection (at a detection limit of 0.4 ug/l) at other open Bay stations. Clearly, cyanide continues to degrade over time and does not accumulate in the water column of the Bay.

Other Shallow Water Discharger Methodology

The purpose of effluent and ambient monitoring by other Shallow Water Dischargers was to confirm that the results obtained by the City of San Jose were observed along other discharge gradients. Monitoring results and mathematical modeling study results were used to estimate the distances from individual discharge points where specific attenuation factor values are attained (see Appendices B and D).

Grab samples of effluent and receiving water were taken at the following nine other Shallow Water Discharge locations.

- American Canyon
- Fairfield Suisun SD
- Las Gallinas Valley SD
- Mt. View SD
- Napa SD

- Palo Alto
- Petaluma
- Sonoma County Water Agency
- Sunnyvale

All samples were analyzed by the City of San Jose WPCP laboratory using the same analytical methods and detection limits employed in the San Jose special study (see Appendix M for a description of the analytical method). Therefore, the data obtained from the above sampling effort is deemed to be high quality and comparable with the City of San Jose and other SWD data.

Other Shallow Water Discharger Results

The characteristic cyanide attenuation curve observed along the San Jose discharge gradient were observed at each of the other Shallow Water Discharger locations either through modeling or empirical measurements (see Appendix D).

Where empirical data were used, attenuation factors were calculated as described above for the City of San Jose results. Where modeling predictions of percent effluent were used, attenuation factors were calculated as follows:

> AF = Dilution factor = 1 / [Percent effluent at a given location on the discharge gradient]

The effluent percentages corresponding to attenuation factors (AF) of 2.25, 3.5 and 4.5 were as follows:

> For AF = 2.25, effluent percentage = 44.4
> For AF = 3.5, effluent percentage = 28.6
> For AF = 4.5, effluent percentage = 22.2

Table 4 provides a summary of distances along individual discharge gradients where specific attenuation factors exist for each of the Shallow Water Dischargers. These distances define the approximate dimensions of attenuation zones for each discharger, depending on the selected AF value.

Table 4. Attenuation Zones for Shallow Water Dischargers

Discharger	*Study Used to Develop AF versus distance curve*	*Date of study*	*Estimated Distance to AF = 2.25*	*Estimated Distance to AF = 3.5*	*Estimated Distance to AF = 4.5*
American Canyon	Empirical data	2005	2,100	3000	NA
Fairfield-Suisun SD	Model Study	2004	15,000	24000	27,000
Las Gallinas Valley SD	Empirical data	2004	800	875	1,200
Mt. View SD	Empirical data	NA	NA	NA	NA
Napa SD	Empirical data	2005	1,500	2500	8,500
Novato SD	Model Study	2004	120	170	190
Palo Alto	Model Study	1997	1,600	2400	3,000
Petaluma	Model Study	2001	0	0	5,500
San Jose Santa Clara	Empirical data	2003-2004	14,700	20000	27,800
Sonoma County Water Agency	Model Study	1997	10,000	15500	17,000
Sunnyvale	Empirical data	2004	1,100	7200	NA
Union SD - Hayward Marsh	NA	NA	NA	NA	NA

NA = Data or Estimation Not Available

Notes:

Attenuation factors are calculated as follows:

Where ambient measurements are available:

AF = [Cyanide concentration in ambient water] / [Cyanide concentration in effluent]

Where percent effluent predictions are available from modeling study:

AF = 1 / [Percent effluent at an ambient location]

AF = 2.25 at 44.4% effluent
AF = 3.5 at 28.6% effluent
AF = 4.5 at 22.2% effluent

Note: In this case, the AF = dilution ratio

Table 5: CYANIDE IN SHALLOW WATER DISCHARGER RECEIVING WATERS (ug/L)

	San Jose	Other SWD Data	ALL DATA
average	0.63	1.43	0.90
std dev	0.71	1.65	1.18
CV	1.14	1.16	1.31
n	149	76	225
90th percentile	1.60	4.00	2.20
99th percentile	3.46	6.70	6.43
max	4.20	6.70	6.70

Appendix M

City of San Jose Modified Analytical Methods for Total Cyanide

The City of San Jose Environmental Services Department used a modified version of Standard Methods 4500-CN B, C and E (Standard Methods, 20th Edition (APHA/AWWA/WEF 1998) Method B – Preliminary Treatment of Samples, Method C – Distillation, and Method E – Colorimetric determination) for the determination of cyanide in effluent and ambient water samples. Modifications to the methods were employed to optimize (lower) the detection limits for measuring total cyanide. Deviations from Standard Methods are shown below in bold.

Samples were preserved by the addition of NaOH to a pH of at least 12 and then stored at 4 degrees Centigrade. At the time of the analysis, **700 ml** of sample was placed in a 1-liter distillation flask. **40 ml of concentrated** sulfuric acid, **35 ml** of a concentrated MgCl2 solution, and 2 grams of sulfamic acid were added to each sample. The distillation equipment consisted of the distillation flask, a cold finger condenser, a sparger and the sparger vessel. An absorber solution of 0.04 N NaOH was added to the sparger vessel. The distillation flask was heated to boiling with a heating mantle and a stream of **nitrogen gas** was bubbled through each sample for **two hours**. The stream of **nitrogen gas** carries the hydrogen cyanide over to the absorbing solution into which the cyanide dissolves. An **8.75-fold concentration** of analyte occurred during the distillation step (**700 ml sample reduced to 80 ml** absorber solution). A 35-ml aliquot of the absorber solution was used for colorimetric analysis. A **35-ml sample** was pipetted into a 50-ml flask, color development reagents were added, and the final volume was brought up to **50 ml**. Therefore, the overall concentration effect was approximately **six-fold**. The color was allowed to develop for seven to fifteen minutes. Sample determination was done using a UV/VIS spectrophotometer set at 578 nm with a **10-cm** sample cell.

This modified procedure provided a Method Detection Limit (MDL) of 0.06 ppb for Bay water and distilled water. The procedure provided a MDL of 0.2 ppb in effluent. This resulted in Practical Quantitation Limits (PQLs) of 0.3 ppb in Bay water and 1.0 ppb in effluent using the protocol described in Standard Methods, 20th edition. In short, seven replicates of reagaent (matrix) water of known analyte concentration were analyzed. The standard deviation of the replicate analysis was multiplied by the appropriate student's t value to obtain the MDL. The PQL was set at five times the MDL.

Reference

City of San Jose. 2004. *Cyanide Attenuation Study*, Watershed Protection Group, Environmental Services Department, September 1.

Appendix N

Evaluation of Biological Community of Shallow Water Discharger Receiving Waters

There is a question whether existing concentrations of cyanide in the immediate vicinity of shallow water dischargers are having an adverse impact on aquatic organisms. A study performed in 1997 in the Palo Alto discharge channel has been reviewed to address this question. The results of this study provide a qualitative understanding of conditions in shallow sloughs near shallow water discharges in the San Francisco Bay area.

Palo Alto Study Description

A comparative study of the Palo Alto discharge channel and a nearby tidal slough was conducted in 1997 to determine if the biological community in the discharge channel was stressed relative to channels not dominated by effluent. The Palo Alto discharge channel is a man-made channel created in the 1950's to convey treated effluent from the City of Palo Alto Water Quality Control Plant to San Francisco Bay. The channel is approximately 2000 feet long and ranges in width from 20 feet at low tide to 40 feet at high tide.

San Francisquito Creek is a tidally influenced natural stream that enters San Francisco Bay approximately 1000 feet northwest of the Palo Alto discharge channel. Water quality in San Francisquito Creek is marginally affected by the Palo Alto effluent discharge. Water quality modeling results performed for the City of Palo Alto in 1997 by RMA, Inc. indicate that the percentage of Palo Alto effluent at the mouth of San Francisquito Creek is approximately 20-30 percent.

The 1997 biological assessment included sampling for benthic organisms and fish at three locations in the discharge channel and three locations in San Francisquito Creek. Benthic samples were collected at low or incoming tide using an Eckman dredge. Three grab samples were taken at each location. Fish were collected at high tide using a bag seine with 0.5 inch mesh. Sediment samples were collected at each location from the center of the flow channel using an Eckman dredge and were analyzed for grain size and organic carbon concentrations.

Palo Alto Study Results

The results of the August 1997 biological assessment of benthic community and fish in the Palo Alto effluent channel indicated that it supported a diverse assemblage of aquatic fauna. The benthic community in the discharge channel was dominated by Arthropods (crustaceans *Corophium alienese* (amphipod), *Grandidierella japonica* (amphipod), and *Nippoleucon oregonensis*). Significant numbers of Mollusks (the clam *Macoma balthica*) and Annelids (oligochaete worms of the species *Tubificidae* and polychaete worms of the species *Eteone* and *Neanthes*) were also present. The types and abundances of organisms present in the channel were deemed to be representative of typical South Bay slough species and not indicative of highly stressed benthic communities. Results from the fish sampling effort indicated that topsmelt (*Atherinops affinis*) and northern anchovy (*Engraulis mordax*) were present in large numbers. These fish species are common to the sloughs of South San Francisco Bay.

As noted previously, a parallel sampling program was performed in San Francisquito Creek in the 1997 study to provide a reference for the sampling results for the discharge channel. Comparisons between the results from the discharge channel and the creek indicated the following:

- Benthic composition and density was similar in the two waters. Both waters support a diverse benthos community with strong numbers of marine/estuarine organisms.

- Mean diversity (as measured by the Shannon-Weaver diversity index) and equitability values for the benthic community were higher in the discharge channel. These values were not indicative of a highly stressed system; instead the values were typical of a tidal slough that experiences significant seasonal salinity variation.

- Numbers of taxa and numerical abundance of benthic organisms and fish (an indicator of productivity) was slightly higher in the creek than in the discharge channel; the hypothesis offered for this difference was a reduced opportunity for primary productivity in the dead-end effluent channel as opposed to the natural creek system tributary to San Francisquito Creek.

- Sediment grain size and organic carbon content were similar in the creek and discharge channel.

In the Conclusions for the 1997 study, it is stated that the discharge channel "supports a diverse and healthy aquatic fauna". In the Executive Summary, it is stated that the "diversity and equitability indices indicate a healthy environment in both waterways".

<u>Discussion</u>

Palo Alto provides a reasonable case study to evaluate local effects of cyanide. This plant is a type of worst-case scenario with respect to cyanide because of three factors: (1) shallow discharge into a dead-end slough, (2) known industrial sources of cyanide to the influent, and (3) the plant processes includes chlorination and biosolids incineration, both documented in-plant sources of cyanide. In addition, of the 225 samples near shallow water discharges, the seven highest receiving water concentrations were documented in the Palo Alto effluent channel. If biological effects of current operations would be detected anywhere in San Francisco Bay, it would be in the Palo Alto receiving waters.

During 1995-1996, the Palo Alto tertiary effluent discharge rate ranged from 20.4 to 43.9 mgd. In the month of August in 1995-1996, the average flow rate was 23.6 mgd. The effluent concentration of cyanide for 1995-1996 ranged from less than 3 to 40 ug/l. Palo Alto's WQCP processes include advanced secondary processes, with activated sludge, nitrification, filtration and chlorine disinfection. Palo Alto is one of two facilities in the Bay area that incinerates its biosolids; return flows air scrubbing system for the incineration process contains cyanide. In the period from 2000 to 2003, effluent cyanide levels for Palo Alto averaged 3.3 ug/l, with maximum levels of 5.0 ug/l. From inspection of the effluent summary statistics presented in Table 16, it is observed that cyanide levels in the Palo Alto effluent are similar to a number of other Shallow Water Dischargers.

The most sensitive saltwater species to free cyanide is the copepod, *Acartia clausi*. The LC50 value for *Acartia* is 30 ug/l; the estimated concentration for no acute effects to *Acartia* is 15 ug/l. *Acartia clausi* is an estuarine copepod that exists globally and is the most abundant zooplankton species in San Francisco Bay (Davis, 1982). It is a prey organism for small fish such as anchovy. Sampling in the Palo Alto discharge channel did not include zooplankton collections, so direct information on the presence or abundance of *Acartia* in the channel is not available from the 1997 study. However, the presence of significant numbers of Northern Anchovy in the discharge channel at levels comparable to those in San Francisquito Creek suggests that prey items in the discharge channel were supportive of upper trophic level organisms.

The most acutely sensitive freshwater species to cyanide is Rainbow trout. This freshwater species would not be expected to be found in the Palo Alto discharge channel, which is a dead-end slough with very limited freshwater habitat. The estimated no acute effect concentration for Rainbow trout is 22 ug/l. In the event Rainbow trout were able to inhabit the discharge channel, acutely toxic conditions would not occur for this sensitive species. The most sensitive freshwater species to chronic effects are brook trout, bluegill and fathead minnow (see Section 6.3.2, Table 13). As for rainbow trout, these obligate freshwater species would not be able to tolerate the salinity conditions in the Palo Alto discharge channel.

Conclusions

Despite levels of cyanide in the Palo Alto effluent channel that exceed the NTR cyanide objective of 1.0 ug/l and the site specific chronic objective of 2.9 ug/l, the biological community in the Palo Alto discharge channel supports a diverse and healthy assemblage of aquatic organisms. This provides qualitative evidence to suggest that the proposed effluent limits and Cyanide Action Plan for Palo Alto and other shallow water dischargers, which will maintain existing effluent concentrations of cyanide, will be protective of aquatic life uses in the vicinity of those discharges.

Reference

Cressey, S. 1997. *Benthos and Fisheries Assessment, Palo Alto Wastewater Treatment Plant Discharge Channel*. Prepared for the City of Palo Alto under subcontract to Larry Walker Associates. November.